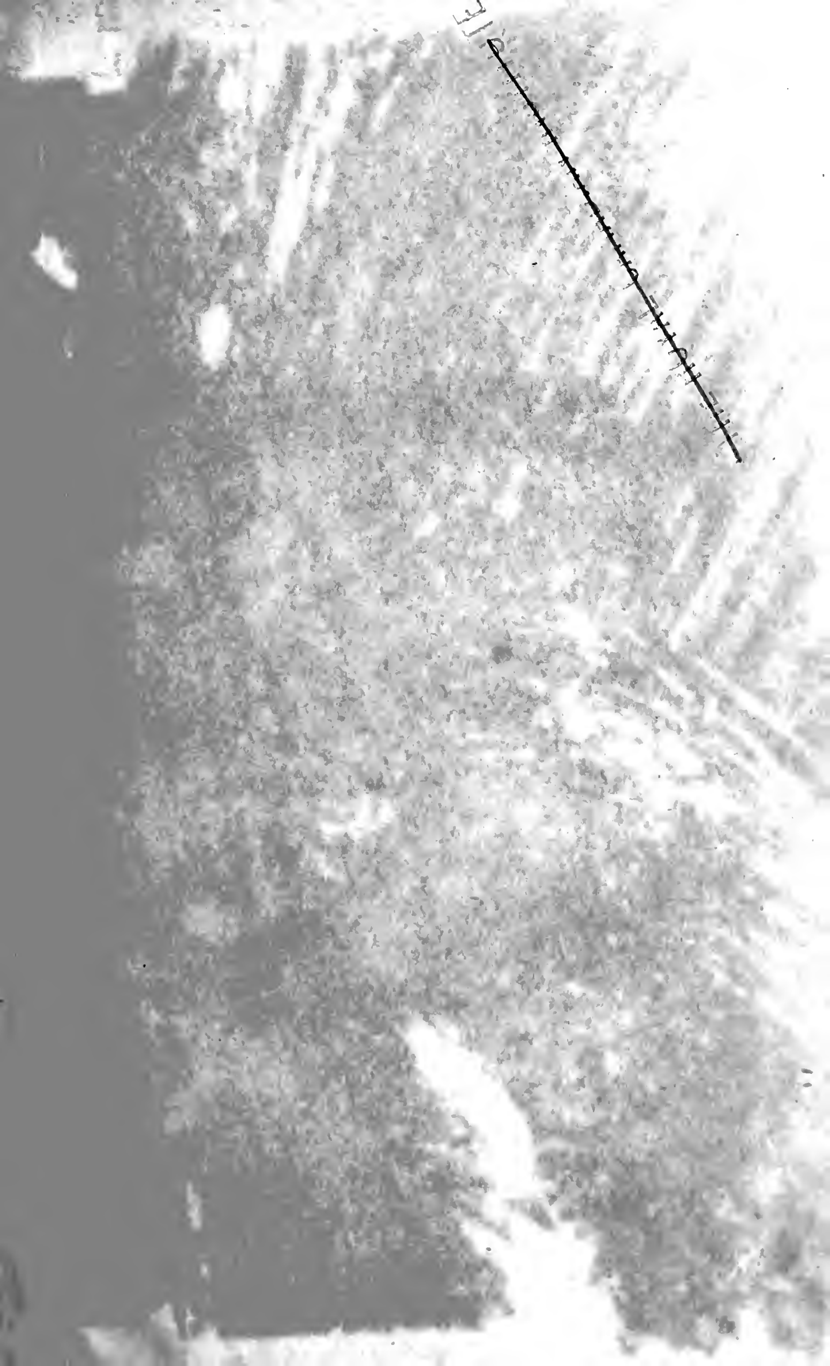

NORTH OF ENGLAND INSTITUTE OF
MINING ENGINEERS.

TRANSACTIONS.

VOL. XIII.

1863-4.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, SANDHILL.

1864.

NEWCASTLE-UPON-TYNE:
ANDREW REID, PRINTING COURT BUILDINGS, SANDHILL.

CONTENTS OF VOL. XIII.

R

S

V

W

Report.

In presenting their Report to the Anniversary Meeting of August the 4th, 1864, the Council have no unpleasing duty to perform. In every respect, the proceedings of the year now brought to a close may be styled satisfactory, whether with regard to the material prosperity of the Institute, the character of the Transactions for the year, or the future prospects of the Society.

The support which the Institution has received during the past year, is on the whole promising. The number of members elected during the twelve months is 26; the losses by death, and other circumstances, amount to 13; leaving the total number of members (graduates included) up to this date 311; which, when compared with the number in August, 1863, exhibits an increase of 15.

Amongst the losses by death, the Council must advert to that of the late Mr. J. Brown, of Darlington, a man of much energy and great practical experience, as well as practical knowledge. The death of Mr. Llewellin, of Glanwern, is also an event much to be regretted.

With respect to the character and value of the printed Transactions of the twelve months now ended, it is proper to remark that both have been enhanced and modified by peculiar circumstances. The meeting of the British Association for the Advancement of Science took place, in this town, within a few days of the Anniversary Meeting of 1863. In the proceedings of the British Association, at that period, many members of this Institution naturally took an important part. Meeting in a district conspicuous for its extensive mining concerns, and for other great branches of industry immediately connected with mining pursuits, one of the most prominent objects of the British Association necessarily was to obtain, from those practically connected with these great branches of industry, full and lucid details, not only of the progress made, but of the modes pursued, in mining for coal, lead, and iron, as well as the details of the manufacturing processes collaterally connected with the leading industrial branches already adverted to.

The papers containing these valuable details are, for the greater part, if not entirely, the work of members of this Society; and they form one of the most unique and interesting series of papers ever published upon this class of industrial pursuits, whether we contemplate the scientific or the engineering knowledge which they embody and exhibit.

Under these circumstances, the Council feel they did right in recommending, and that this Society did right in adopting the recommendation, that these papers (under permission of the committees of the British Association, which was gladly accorded) should also be read at the meetings of the members of this Institute, and form part and parcel of its Transactions.

As they have already, in another form, been before the public, and as the public, by the purchase of a large edition, may be said to have passed judgment upon them, it would be superfluous here to particularise any. Suffice it, then, to say, that without doubt they form a most admirable view of the Industrial Resources of the Northern English counties, and one, the accuracy of which may, in every point, be relied upon.

To one of these papers, the Council may be permitted to say, a peculiar interest is attached with a view to the future. The essay alluded to is that by Mr. John Marley, on the discovery of the basin of rock-salt in the vicinity of Middlesbrough.

The members of the Institution are already aware that, through the cheapness of fuel on the river Tyne, and the spirit of inquiry and enterprise evinced by the inhabitants of Newcastle and the neighbouring counties, the manufacture of soda in all its preparations, has been, within a comparatively few years, commenced and established; the salt mines of Cheshire affording the muriate of soda, the cheap decomposition of which forms the basis of the manufacture. To this already great trade, it is hoped, the discovery of the rock-salt deposit, near Middlesbrough, may give an additional and important impetus. The extent of the Middlesbrough salt basin is, at present, altogether a matter of speculation; nor are its depth and quality yet sufficiently ascertained to be spoken of with any degree of certainty. The fact, however, is patent that, within a few miles of the Tyne district, and a little to the south of the Tees, a deposit of salt-rock of unknown extent is known to exist; and that a supply of this mineral should be allowed to remain valueless, and without its influence on the enterprise and energy of the district is hardly to be supposed.

The Council may further be permitted to advert to Messrs. Wood and Boyd's very elaborate and curious paper on the "Wash" or "Drift" of the Durham Coal-field, as well as to the interesting paper, by Mr. Matthias Dunn, on the New-red-sandstone of Cumberland, with the discussion thereupon. That coal underlies this formation has been placed beyond doubt by the experiments already made; and it is now a matter of national importance that all coal-fields existing within these islands should be discovered, and, as far as practicable, explored.

It must be in the recollection of some here present that it has been a subject of discussion before this Institute, whether the Coal-field of Yorkshire and that of this district may not be identical; although the former may be thrown down to a great depth before it reaches the newer formation of the Cleveland district, against which the Coal-field of South Durham may be said to abut. It is a prevalent idea with many persons possessed of geological knowledge and experience, who are fully alive to the importance of the question, that an investigation, under the sanction of Government, of this matter might be recommended both as desirable and practicable. On this the Council must refrain from giving any opinion. There need not, however, be any hesitation in affirming that, were such an idea to be generally entertained by those capable of dealing with such questions, any expression of opinion by this body, whether with regard to the policy, the practicability, or the probable cost of such an undertaking would have great weight.

In conclusion, the Council are glad to draw the attention of the meeting to the favourable statement of the Finance Committee. It is agreeable in every point of view, and it may now perhaps be a matter for consideration of the Council for the ensuing year, whether it may not be expedient to reprint, under certain modifications to lessen the cost, those volumes of the Transactions which are now out of print, but for which there are frequent and earnest inquiries.

ADVERTISEMENT.

THE Institution is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

Finance Report.

YOUR Committee have pleasure in reporting a decided improvement in the Finances of the Institute.

Compared with last year, the Income exhibits an improvement of £58, due to the increased rate of interest now receivable on the Stephenson Bequest, together with a continued increase in the number of Members (298 increased to 310).

The Expenditure has also been reduced £77, due in great measure to the attention paid by your Council in avoiding, as far as was expedient, the publishing of unnecessarily expensive Maps and Diagrams.

In the Expenditure Accounts of this year, there appears an amount of £40 for a Grant to Natural History Society, which was an unsettled account for the previous year.

The comparison of accounts for 1864, as compared with 1863, will therefore stand thus:—

Increase of Income in 1864 over 1863	£58	
Decrease of Expenditure in 1864 over 1863	77	
Unsettled Account of 1863 paid in 1864	40	
		£175
The actual Income of year 1864 is	£901	
The Actual Expenditure for year 1864, not including the above unsettled account of 1863	619	
Balance, being Increase of Income over Expenditure for year 1864		£282

Your Committee may point with satisfaction to the new item of £8 8s. 0d. for Subscriptions from Graduates, who have become members during the past year under the new regulation.

G. B. FORSTER.
LINDSAY WOOD.
JOHN DAGLISH.

THE TREASURER IN ACCOUNT WITH THE NORTH

For the Year ending

1863.	Dr.					£ s. d.
July 1.—To Balance in hands of Treasurer from Eleventh Year			£113 15 3			
„ ditto ditto Liquidators of District Bank			203 19 5			
„ Robert Stephenson's, Esq., Legacy, invested on Mortgage of Northumberland Dock Rates ...			2000 0 0			
						2317 14 8
1864.						
July 1.—To Interest on ditto, from June 6, 1863, to June 6, 1864			95 0 0			
Less Income Tax			2 14 0			
						92 6 0
„ Arrears of 1863 Subscriptions received ...			25 4 0			
„ Subscriptions received for this year from 282 Members			592 4 0			
„ ditto ditto 8 Graduates			8 8 0			
„ ditto ditto from Colliery Owners, viz.:—						
Black Boy	£4 4 0					
Leasingthorne	2 2 0					
Westerton	2 2 0					
East Holywell	2 2 0					
Haswell	4 4 0					
Ryhope	4 4 0					
Hetton	10 10 0					
North Hetton	6 6 0					
Grange	2 2 0					
Kepier Grange	2 2 0					
Lambton	10 10 0					
South Hetton and Murton ...	8 8 0					
Stella Coal Company	2 2 0					
Whitworth	2 2 0					
			63 0 0			
						688 16 0
„ Received for Numbers of Bristol Mining School Lectures...						2 9 8
„ Received of John Taylor, Esq., for Old Fossil Cabinet ...						4 0 0
„ Sales of Publications, per A. Reid:—						
From June 30, 1863, to Dec. 31, 1863 ...			£56 2 8			
From Dec. 31, 1863, to June 30, 1864 ...			57 12 0			
						113 14 8
						£3219 1 0

OF ENGLAND INSTITUTE OF MINING ENGINEERS.

July 1st, 1864.

1864.	Cr.			£ s. d.
July 1.—	By paid A. Reid for Reprinting 200 Copies of Vol. II.		£148 0 0	
	,, Ditto, Printing and Publishing Account, from June 30 to Dec. 31, 1863 ...	£181 6 0		
	,, Ditto, from Dec. 31, 1863, to June 30, 1864	190 11 0		
			371 17 0	
	,, Ditto, Binding and Sewing Copies of Vols. II., III., IV., VI., VII., VIII , IX., X., XI., & XII.		54 8 11	
	,, Ditto, Covers for "Parts," Circulars, &c. ...		33 2 3	
	,, Ditto, Advertising Transactions		3 12 4	
	,, Ditto, Postage Stamps		22 8 8	
				633 9 2
	,, Paid Secretary for Postage Stamps		17 9 6	
	,, Paid Assistant Secretary for ditto		1 0 0	
	,, Paid Treasurer for ditto, &c.		6 2 6	
				24 12 0
	,, Paid Secretary's Salary for year ending June 30, 1864		25 0 0	
	,, Paid Assistant Secretary's ditto		35 0 0	
	,, Paid R. Curtice, Reporting for ditto		12 12 0	
	,, Paid ditto Preparing Index to Vols. of Transactions		12 0 0	
				84 12 0
	,, Paid Natural History Society Contribution for extra Geological Cases		40 0 0	
	,, Paid Natural History Society Subscription for year ending Oct. 3, 1863		20 0 0	
				60 0 0
	,, Paid Insurance on Property at Institute Rooms		0 16 6	
	,, Paid ditto ditto called "Stock," per A. Reid		2 10 0	
				3 6 6
				805 19 8
	,, Balance in hands of Treasurer at this date ...		209 1 11	
	,, Balance in hands of Liquidators of District Bank, being Proportion of Deposit yet unpaid		203 19 5	
	,, R. Stephenson's, Esq., Legacy, invested on Mortgage of Northumberland Dock Rates ...		2000 0 0	
				2413 1 4
				£3219 1 0

GENERAL STATEMENT, JULY, 1864.

1864.	Liabilities.	1864.	Assets.		£	s.	d.
		July 1.	—By Cash in hands of Treasurer ...	£209 1 11			
			„ Balance in hands of Liquidators of District Bank	203 19 5			
			„ Amount Invested on Mortgage of Northumberland Dock Rates	2000 0 0			
					2413	1	4
			„ Arrears of Members' Subscriptions for years 1863 and 1864	86 2 0			
			Less due by those whose Membership has been discontinued	33 12 0			
			„ Net Arrears at this date ...		52	10	0
			„ Value of 325 Bound Volumes of Transactions	170 12 6			
			„ Ditto of 941 Sewed ditto ditto	399 18 6			
			„ Ditto of 169 Reprinted Copies Vol. II., in Sheets	59 3 0			
			„ Ditto of Plates and Sheets belonging to Vol. XIII., unfinished at this date ...	125 0 0			
			„ Ditto of 10 Copies of "Wales on Ventilation"	1 5 0			
					755	19	0
					£3221	10	4

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The Right Honourable the Earl of Durham.
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30 Bourne, P., Whitehaven, Cumberland.
31 Bourne, S , West Cumberland Hematite Iron Works, Workington.
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54 Cochrane, C., Woodside Iron Works, near Dudley.
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58 Collis, William Blow, Amblecote, Stourbridge, Worcestershire.
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63 Cooper, Thomas, Park Gate Colliery, Rotherham, Yorkshire.
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74 Crone, S. C., Killingworth Colliery, Newcastle-on-Tyne.
75 Curry, James, Cassop Colliery, Ferry Hill.

76 Daglish, J., Rainton Colliery, Fence Houses.
77 Dakers, Thomas, Byers Green, Ferry Hill.
78 Darlington, James, Springfield House, Coppull, near Chorley, Lancashire.
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89 Dunn, C.E., Thomas, Windsor Bridge Iron Works, Manchester.

90 Easton, J., Nest House, Gateshead.
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92 Elliot, W., Weardale Iron Works, Towlaw, Darlington.
93 Embleton, T. W., Middleton Hall, Leeds, Yorkshire.

94 Feare, G., Camerton Coal Works, Bath.
95 Fletcher, C.E., Jos., 69, Lowther Street, Whitehaven.

96 Fletcher, John, Clifton Colliery, Manchester, Lancashire.
97 Fletcher, Isaac, Clifton Colliery, Workington.
98 Foord, J. B., General Mining Association Secretary, 52, Broad Street, London.
99 Forster, J. H., Old Elvet, Durham.
100 Forster, G. B., Backworth, Newcastle-upon-Tyne.
101 Forster, Thomas E., 7, Ellison Place, Newcastle-upon-Tyne.
102 Fothergill, Joseph, Cowpen Office, Quay, Newcastle-upon-Tyne.
103 Fowler, Geo., Donisthorpe, Ashby-de-la-Zouch, Leicestershire.
104 Firth, William, Birley Wood, Leeds.
105 Fryar, Mark, Eighton Moor Colliery, Gateshead.

106 Gainsford, William Dunn, Darnall Hall, Sheffield.
107 Gardner, M. B., Tondû Iron Works, Bridge End, Glamorganshire.
108 Gillett, F. C., 5, Wardwick, Derby.
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126 Hawthorn, C.E., W., Engineer, Newcastle-upon-Tyne.
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128 Heath, Robert, Biddulph Valley Coal and Iron Works, near Tunstall, Staffordshire.
129 Heckels, R., Pensher House, Fence Houses.

130 Hedley, Edward, Osmaston Street, Derby.
131 Heppell, Thomas, Little Town Colliery, Durham.
132 Hetherington, David, Netherton, Morpeth.
133 Hewlett, Alfred, Haigh Colliery, Wigan, Lancashire.
134 Higson, Jacob, 94, Cross Street, Manchester.
135 Hodgetts, Alfred, Dawson Place, Whitehaven, Cumberland.
136 Hodgson, R., Engineer, Whitburn, Monkwearmouth, Sunderland.
137 Hood, Archibald, Whitehill Colliery, Lasswade, Edinburgh.
138 Horsley, W., Seaton Sluice, Hartley, North Shields.
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140 Howard, Wm. Frederick, Staveley Works, Chesterfield, Derbyshire.
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146 Hurst, T. G., Backworth Colliery, Newcastle-upon-Tyne.

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148 Jackson, Henry, Astley and Bedford Collieries, Tyldesley, Manchester.
149 Jackson, John, Warren House, Ashby-de-la-Zouch.
150 Jeffcock, P., Midland Road, Derby.
151 Jenkins, William, M.E., 4, Woodfield Place, Roath, Cardiff.
152 Jobling, T. W., Point Pleasant, Wallsend, Newcastle-upon-Tyne.
153 Johnson, John, Tynemouth.
154 Johnson, R. S., Haswell, Fence Houses.
155 Johnson, Henry, Dudley, Worcestershire.
156 Joicey, John, Urpeth Lodge, Fence Houses.
157 Jones, E., Granville Lodge, Wellington, Salop.

158 Kenrick, Wm. Wynn, Erbistock, near Ruabon, Denbighshire.
159 Kerr, John, Auchinheath, Leshmahagow, Lanarkshire, N.B.
160 Kimpster, W., Quay, Newcastle-upon-Tyne.
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162 Knowles, John, Pendlebury Colliery, Manchester.
163 Knowles, Thomas, Ince Hall, Wigan.
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174 Liddell, M., Tynemouth.
175 Lindop, James, Bloxwich, Walsall, Staffordshire.
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177 Lishman, Wm., Bunker Hill, Fence Houses.
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179 Llewellin, David, Glanwern, Pontypool, Monmouthshire.
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183 Maddison, W. P., Thornhill Colliery, Dewsbury, Wakefield.
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185 Maddison, W., Coxlodge Colliery, Newcastle-upon-Tyne.
186 Mallet, Robert, C.E., F.R.S., 11, Bridge Street, Westminster, London, S.W.
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188 Marshall, Robert, 10, Three Indian Kings Court, Quayside, Newcastle-upon-Tyne.
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190 May, George, North Hetton Colliery, Fence Houses.
191 McCulloch, H. J., East Mount, York.
192 McGhie, Thos., Cannock Chase Colliery, Walsall, Staffordshire.
193 McGill, Robert, St. Helen's Colliery, St. Helen's, Lancashire.
194 McMurtrie, J., Radstock Colliery, Bath.
195 Middleton, J., Davison's Hartley Office, Quay, Newcastle-on-Tyne.
196 Miller, Jun., William, College Street, Whitehaven.
197 Moody, R. W., New Zealand.

198 Monkhouse, Joseph, Gilcrux Colliery, Cockermouth.
199 Morison, David P., Pelton Colliery, Chester-le-Street.
200 Morris, William, Waldridge Colliery, Chester-le-Street.
201 Morton, H., Lambton, Fence Houses.
202 Morton, J. H., Garforth House, Leeds.
203 Morton, H. T., Lambton, Fence Houses.
204 Muckle, John, Elemore Colliery, Easington Lane, Fence Houses.
205 Mulcaster, H., Colliery Office, Whitehaven.
206 Mulcaster, Joshua, Crosby Colliery, Maryport.
207 Mulvany, Wm. Thos., 1335, Carls Thor, Dusseldorf on the Rhine, Prussia.
208 Murray, T. H., Chester-le-Street, Fence Houses.

209 Napier, Colin, Westminster Colliery, Wrexham, Denbighshire.
210 Newall, Robert Stirling, Fern Dene, Gateshead.
211 Nicholson, William, Seghill Colliery, Newcastle-upon-Tyne.
212 Nicholson, Marshall, West Ardsley Colliery, Wakefield, Yorkshire.

213 Oliver, Wm., Stanhope Burn Offices, Stanhope, Darlington.

214 Palmer, C. M., Quay, Newcastle-upon-Tyne.
215 Palmer, A. S., Port Mulgrave, Redcar, Yorkshire.
216 Paton, Wm., Alloa Colliery, Alloa, North Britain.
217 Peace, Maskell Wm., Solicitor, Wigan, Lancashire.
218 Pearce, F. H., Bowling Iron Works, Bradford, Yorkshire.
219 Pease, J. W., Woodlands, Darlington.
220 Peel, John, Springwell Colliery, Gateshead.
221 Pilkington, Jun., Wm., St. Helen's, Lancashire.
222 Potter, E., Cramlington, Newcastle-upon-Tyne.
223 Potter, W. A., Monk Bretton, Barnsley, Yorkshire.
224 Powell, T., Lower Duffryn Colliery, Aberdare, Glamorganshire.

225 Ramsay, J. T., Walbottle Colliery, Newcastle-upon-Tyne.
226 Ravenshaw, J. H., Grange, Newton-in-Cartmel, Lancashire.
227 Rayner, J. T., Methley House, Wakefield.
228 Reed, Robert, Felling Colliery, Gateshead.
229 Rees, Daniel, Letty Shenkin Colliery, Aberdare, Glamorganshire.
230 Reid, P. S., 15, Beaufort Buildings, Strand, London, W.C.
231 Richardson, Dr., Framlington Place, Newcastle-upon-Tyne.

232 Robinson, R., Stanley Colliery, Pease's West, Darlington.
233 Robson, J. S., Butterknowle Colliery, Staindrop, Darlington.
234 Robson, M. B., Field House, Borough Road, Sunderland.
235 Robson, Neil, 127, St. Vincent Street, Glasgow.
236 Robson, Thomas, Lumley Colliery, Fence Houses.
237 Rockwell, Alfd. P., M.A., Norwich, Connecticut, United States, America.
238 Rose, Thomas, Millfield Iron Works, Bilston, Wolverhampton, Staffordshire.
239 Ross, A., Shipcote Colliery, Gateshead.
240 Rosser, Wm., Mineral Surveyor, Llanelly, Carmarthenshire.
241 Routledge, William, Shincliffe Colliery, Durham.
242 Russell, Robert, Gosforth Colliery, Newcastle-upon-Tyne.
243 Rutherford, J., South Tyne Colliery, Haltwhistle, Northumberland.

244 Sanderson, Jun., R. B., West Jesmond, Newcastle-upon-Tyne.
245 Sanderson, Thomas, Seaton Delaval, Newcastle-upon-Tyne.
246 Scott, George, Albion Mines, Pictou, Nova Scotia.
247 Shield, Hugh, Pittington Colliery, Durham.
248 Shone, Isaac, Mineral Surveyor, Grove Bank, near Wrexham, Denbighshire.
249 Simpson, L., South America, per E. Simpson, Dipton, Gateshead.
250 Simpson, R., Ryton, 7, Quay, Newcastle-upon-Tyne.
251 Simpson, John Bell, Moor House, Ryton, Newcastle-upon-Tyne.
252 Smith, F., Bridgewater Canal Office, Manchester
253 Smith, Jun., J., Monkwearmouth Colliery, Sunderland.
254 Smith, Edmund J., 14, Whitehall Place, Westminster, London, S.W.
255 Sopwith, T., 43, Cleveland Square, London, W.
256 Southern, G. W., Chilton Hall, Ferry Hill.
257 Spark, H. K., Darlington, County of Durham.
258 Spencer, Jun., W., Eston Mines, Middlesbro'.
259 Steavenson, A. L., Skelton Mines, Guisbro', Yorkshire.
260 Steel, Charles, Ellenborough Colliery, Maryport, Cumberland.
261 Stenson, W. T., Whitwick Colliery, Coalville, near Leicester.
262 Stephenson, George R., 24, Great George Street, Westminster, London, S.W.
263 Stobart, H. S., Witton-le-Wear, Darlington.
264 Swallow, R. T., Pontop Colliery, Gateshead.
265 Swallow, John, Harton Colliery, South Shields.

266 Taylor, H., Earsdon, Newcastle-upon-Tyne.
267 Taylor, H., 13, Ellison Place, Newcastle-upon-Tyne.
268 Taylor, J. Earsdon, Newcastle-upon-Tyne.
269 Telford, W., Cramlington, Newcastle-upon-Tyne.
270 Thomas, George, Wallend Colliery, Bloxwich, Walsall.
271 Thompson, John, Marley Hill Colliery, Gateshead.
272 Thompson, T. C., Milton Hall, Carlisle, Cumberland.
273 Thomson, Alex., Omoa Iron Works, Motherwell, North Britain.
274 Thorman, John, Ripley, Derbyshire.
275 Tone, C.E., John F., Westgate Street, Newcastle-upon-Tyne.
276 Trotter, J., Newnham, Gloucestershire.
277 Truran, Matthew, Dowlais Iron Works, Merthyr Tydvil, Glamorganshire.

278 Vaughan, John, Middlesbro'-on-Tees.
279 Vaughan, Thomas, Middlesbro'-on-Tees.
280 Vaughan, William, Middlesbro'-on-Tees.
281 Verner, Albert, Framwellgate Colliery, Durham.

282 Wales, T. E., Brunswick Place, Swansea, Wales.
283 Ward, Henry, Priestfield Iron Works, Oaklands, Wolverhampton.
284 Ware, W. H., The Ashes, Stanhope, Weardale.
285 Warrington, John, Kippax, near Leeds.
286 Watkin, Wm. John Laverick, Woodifield and Whitelee Collieries, Crook, Darlington.
287 Watson, W., High Bridge, Newcastle-upon-Tyne.
288 Watson, Joseph J. W., No. 10, Rue de Calvaire, Nantes, Loire Infre.
289 Webster, R. C., Ruabon Collieries, Ruabon, Denbighshire.
290 Willis, James, Grange Colliery, Durham.
291 Wilmer, F. B., Usworth Colliery, Gateshead.
292 Wilson, J. B., Haydock, near St. Helen's, Lancashire.
293 Wilson, R., Flimby Colliery, Maryport, Cumberland.
294 Wilson, J. Straker, Ruardean Villa, near Newnham, Gloucestershire.
295 Wilson, T. M., Forest Hall, Benton, Newcastle-upon-Tyne.
296 Wood, C. L., Black Boy Colliery, Bishop Auckland.
297 Wood, Lindsay, Hetton Colliery, Fence Houses.
298 Wood, N., Hetton Hall, Fence Houses.
299 Wood, W. H., West Hetton, Ferry Hill.
300 Wood, John, Flockton Colliery, Wakefield, Yorkshire.

301 Wood, William O., Brancepeth Colliery, Durham.
302 Woodhouse, J. T., Midland Road, Derby.
303 Wright, C. Tylden, Shireoak Colliery, Worksop, Nottinghamshire.

Graduates.

304 Armstrong, L., Cowpen Colliery, Blyth, Morpeth.
305 Bainbridge, Emerson, Rainton Colliery, Fence Houses.
306 Heslop, James, West Rainton, Fence Houses.
307 Maughan, James N., Townley Colliery, Ryton, Newcastle.
308 Peile, William, Whitehaven, Cumberland.
309 Sopwith, Arthur, Spain.
310 Taylor, W. N., Ryhope Colliery, Sunderland.
311 Wright, George H., Rainton Colliery, Durham.

List of Subscribing Collieries.

Owners of Stella Colliery, Ryton, Newcastle-on-Tyne.
,, Grange Colliery, Durham.
,, Kepier Grange Colliery, Ferry Hill.
,, Leasingthorne Colliery, Ferry Hill.
,, Westerton Colliery, Ferry Hill.
,, Poynton and Worth Collieries, Stockport, Cheshire.
,, Black Boy Colliery, Bishop Auckland.
,, North Hetton Colliery, Fence Houses.
,, Haswell Colliery, Durham.
,, South Hetton and Murton Collieries, Fence Houses.
,, Earl of Durham, Lambton Collieries, Fence Houses.
,, Seghill Colliery, Seghill, near Newcastle.
,, East Holywell Colliery, North Shields.
,, Hetton Collieries, Fence Houses.
,, Whitworth Colliery, Ferry Hill.

Rules.

1.—The objects of the North of England Institute of Mining Engineers are to enable its members to meet together at fixed periods, and to discuss the means for the Ventilation of Coal and other Mines, the Winning and Working of Collieries and Mines, the Prevention of Accidents, and the Advancement of the Science of Mining generally.

2.—The Members of the North of England Institute of Mining Engineers shall consist of four classes of Members, viz.:—Ordinary Members, Life Members, Graduates, and Honorary Members.

3.—Ordinary and Life Members shall be persons practising as Mining Engineers, and other persons connected with or interested in Mining.

4.—Graduates shall be persons engaged in study to qualify themselves for the profession of Mining Engineers.

5.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—The Annual Subscription of each Ordinary Member shall be £2 2s., payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

7.—The Annual Subscription of each Graduate shall be £1 1s. payable in advance, and the same is to be considered due and payable on the first Saturday of August in each year, or immediately after his election.

8.—All persons who shall at one time make a Donation of £20 or upwards, shall be Life Members.

9.—Each Subscriber of £2 2s. annually (not being a member), shall be entitled to a ticket to admit one person to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s. subscribed annually, another person shall be admissible up to the number of five persons; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the proceedings of the Institute sent him.

10.—Persons desirous of being admitted into the Institute as Ordinary Members, Life Members, or Graduates, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The nomination shall be in writing and signed by the proposers, and shall state the name and residence of the individuals proposed, whose election shall be balloted for at the next following General Meeting, and during the interval notice of the nomination shall be exhibited in the Society's room. Every person proposed as an Honorary Member shall be recommended by at least five Members of the Society, and elected by ballot at the following General Meeting. A majority of votes shall determine every election.

11.—The Officers of the Institute shall consist of a President, four Vice-Presidents, and twelve Councillors, who, with the Treasurer and Secretaries (if Members of the Institute), shall constitute a Council for the direction and management of the affairs of the Institute; all of which Officers shall be elected at the Annual Meeting, and shall be eligible for reëlection, with the exception of the three Councillors whose attendances have been fewest, and such Vice-Presidents as have held office for three consecutive years; but such Members are eligible for reëlection after being one year out of office. All Officers, with the exception of the paid Officers (who need not necessarily be Members of the Institute), to be nominated at the General Meeting next before the Annual Meeting; a list of whom, with voting papers, shall be posted to every Member at least fourteen days previous to the Annual Meeting. All nomination and voting papers must be in writing, and signed by the respective members, and delivered personally or forwarded under cover, and in the latter case signed, sealed, and addressed to the Secretary, so as to be in his hands before the hour fixed for the nomination or election of Officers. The Chairman shall, in all cases of voting, appoint scrutineers of the lists, and the scrutiny shall commence on the conclusion of the other business of the meeting. At meetings of the Council, five shall be a quorum, and the Minutes of the Council's proceedings shall be at all times open to the inspection of the Members of the Institute.

12.—That the Vice-Presidents who have become, or may become, ineligible from having held office for three years, shall be, *ex officiô*, Members of the Council for the following year.

13.—A General Meeting of the Institute shall be held on the first Thursday or Saturday, alternately, of every Month (except in January and July), at twelve o'clock noon, or two o'clock if on Saturday; and the General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special Meeting of the Institute may be called whenever the Council shall think fit, and also on a requisition to the Council signed by ten or more Members.

14.—Every question which shall come before any meeting of the Institute shall be decided by the votes of the majority of the Ordinary and Life Members then present.

15.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed by him according to the direction of the Council.

16.—All papers sent for the approval of the Council shall be accompanied by a short abstract of their contents.

17.—The Council shall have power to decide on the propriety of communicating to the Institute any papers which may be received, and they shall be at liberty, when they think it desirable, to direct that any paper read before the Institute shall be printed and transmitted to the Members. Intimation, when practicable, shall be given at the close of each General Meeting of the subject of the paper or papers to be read, and of the questions for discussion, at the next Meeting; and notice thereof shall be affixed in the rooms of the Institute a reasonable time previously. The reading of papers shall not be delayed beyond such hour as the President may think proper, and if the election of Members or other business should not be despatched soon enough, the President may adjourn such business until after the discussion of the subject for the day.

18.—Members elected at any Meeting between the Annual Meetings, shall be entitled to all papers issued in that year.

19.—The Copyright of all papers communicated to and accepted by the Institute shall become vested in the Institute; and such communications shall not be published for sale, or otherwise, without the permission of the Council.

20.—All proofs of discussion forwarded to Members for correction must be returned to the Secretary not later than three days from the date of their receipt.

21.—The Institute is not, as a body, responsible for the facts and opinions advanced in the papers which may be read, nor in the abstracts of the conversations which may take place at the meetings of the Institute.

22.—The Author of each paper read before the Institute shall be allowed *twelve* copies of such paper (if ordered to be printed) for his own private use.

23.—The Transactions of the Institute shall not be forwarded to Members whose subscription is more than one year in arrear.

24.—No duplicate copies of any portion of the proceedings shall be issued to any of the Members unless by written order from the Council.

25.—Each Member or Graduate of the Institute shall have power to introduce a stranger to any of the General Meetings of the Institute, and shall sign, in a book kept for the purpose, his own name as well as the name and address of the person introduced; but such stranger shall not take part in any discussion or other business, unless permitted by the meeting to do so.

26.—No alteration shall be made in any of the Laws, Rules, or Regulations of the Institute, except at the Annual General Meeting, or at a Special Meeting and the particulars of every such alteration shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of, or addition to, the Rules.

ERRATA.

Page 18, line 7, for *wire* read *hempen.*

Page 170. Note to *Cyprina Islandica.*—Fragments of this characteristic boreal shell were first discovered in the superficial deposits of this district by Mr. Godwin-Austen and Mr. E. W. Binney. The first fragments were found in a raised beach overlying the Magnesian-limestone in Tynemouth Castle yard, and afterwards, in a deposit which appeared to be Boulder-clay, near Cullercoats. On the south side of the Tyne, fragments have been found rather plentifully in a rubble above the Boulder-clay, some of which bear distinct glacial markings.—R. H.

Page 203, line 11, for *below* read *above.*

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, OCTOBER 1, 1863, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes,

The following gentlemen were elected members, &c., of the Institute:— Mr. Henry J. M'Cullock, York; Mr. Ralph Brown, Ryhope Colliery, Sunderland; Mr. W. N. Taylor (a graduate), Ryhope Colliery, Sunderland; Mr. Wm. Nicholson, Seghill Colliery, Newcastle; Mr. Matthew Harper, Whitehaven, Cumberland; Mr. William Peile (a graduate), Whitehaven, Cumberland; and Mr. Joseph Anderson, solicitor, Westgate Street, Newcastle-upon-Tyne.

The President said, they were aware that, at the last meeting of the Institute, instructions were given to prepare a paper to be read at the meeting of the British Association in Newcastle. The preparation of that paper was deputed to Mr. John Taylor, Mr. Marley, Mr. Whitwell Pease, and himself. The resolution was to the effect that the paper should be read before the British Association; and a communication was made to the Secretary of the Association, inquiring whether any paper, after having been read to the Association, would be allowed to be embodied in the Proceedings of the Institute. There was a letter, from Mr. Griffith, the Secretary of the Association, saying that the paper might be read to the British Association, and afterwards embodied in the Proceedings of the Institute. It was deemed advisable that the paper should be printed, so that it could be circulated amongst certain members of the British Association. It now became his duty to ask them to pass a resolution that

that paper should be incorporated with the Proceedings of the Institute. The Council thought it advisable that it should be incorporated with Vol. XII. of the Proceedings, as the papers read previous to August scarcely formed the usual bulk of papers in a volume. The resolution would, therefore, be—"That the sectional paper read before the British Association, 'On Coal, Coke, and Coal Mining,' be read *pro formâ*, for the purpose of being incorporated with the papers forming Vol. XII. of the Institute's Transactions, subject to any revisions and alterations to be made by the writers." He believed that some additions were proposed to be made to the paper, and, therefore, the latter portion of the resolution was intended to meet that case. The writers of the paper would confer together, and probably would suggest some alterations, improvements, or additions, and which, it seemed advisable, should also be printed, so that the paper itself, and those improvements, could come forward for discussion at the next monthly meeting of the Institute, if they could be printed in time.

Mr. Berkley inquired whether it was proposed to alter the present printed paper, or to add the alterations and improvements to it in the form of addenda.

The President said, it was not desirable to alter the present paper, as it was already in type. If the alterations were extensive, they could be embodied in a supplement.

The resolution was carried.

The President said, the next subject for consideration was the paper "On the Ventilation of Underground Boilers," by Messrs. William Armstrong and John Daglish; but as a gentleman was present for the purpose of exhibiting and explaining a new lock for safety-lamps, perhaps it would be better to hear him at once.

Mr. P. Devisme, teacher of modern languages, North Road, Durham, who is the agent for the inventor of the patent safety-lamp lock, then produced an air-pump, and three common safety-lamps. The patent, as explained by Mr. Devisme, was taken out for the lock merely. It is self-locking, and there is a valve at the bottom of the lamp, to which a flexible tube, connected with the air-pump, is applied, and on the air being exhausted by the pump, the lamp is unlocked by a very simple apparatus. The invention, it was stated, could be applied to any kind of safety-lamp. The lamp, when locked, could not be opened without using the air-pump. The locks were manufactured in France, and Mr. Devisme was instructed by the manufacturer to grant licences to use the patent.

At the request of the President, Mr. Devisme undertook to supply a drawing of the lock for the use of the Institute, and also to leave a lamp with them for a short time for examination by the members.

The PRESIDENT then said, that before they went into the discussion of the paper of Messrs. Armstrong and Daglish, he should read a letter to them, which he had received from Mr. Warrington Smyth, President of Section C of the British Association Meeting. The letter accompanied a document conveying the thanks of the undersigned Members and Associates of the British Association who accompanied the excursion to Canonbie, on Saturday, August 29th, on behalf of themselves and their Associates, to the President and Members of the Northern Institute of Mining Engineers, for the pleasure and information they had received on that occasion.

(Copy.)

The undersigned, Members and Associates of the British Association who accompanied the Excursion to Canonbie on Saturday, August 29th, beg leave, on behalf of themselves and their associates, to express their grateful thanks to the President and Members of the Northern Institute of Mining Engineers, for the pleasure and information which they received on that occasion, and their admiration of the skill and labour displayed in the preparation of the Books, Maps, and Sections, describing the district, which have a permanent value of the highest kind.

(Signed) WARRINGTON W. SMYTH, President of Section C.
J. BETE JUKES, M.A., F.R.S., etc., V.P. Section C.
SIR HARRY PARKES.
JAMES R. NAPIER, Glasgow.
TRENHAM REEKS, Royal School of Mines, London.
W. J. MACQUORN RANKINE, President of Section A.
ANDREW WYLEY.
SAMUEL DOWNING, C.E., M.R.I.A., F.C.D.
ROBERT MALLET, F.R.S., C.E.
REV. S. W. KING, F.G.S.
PROFESSOR MORRIS.
&c., &c.

The PRESIDENT then said, they would now take the discussion upon the paper of Messrs. Armstrong and Daglish, "On the Ventilation of Underground Boilers." It was printed in April of this year. He inquired if the authors of that paper had any additional observations to offer to them in illustration of the subject.

Mr. DAGLISH—There is nothing additional that I am aware of. The boiler specially referred to in that paper is still at work, and is answering satisfactorily.

The PRESIDENT—And producing the effect you state in the paper?

Mr. DAGLISH—Yes.

The PRESIDENT—It is certainly a very important matter if it accomplishes the object without abstracting any large quantity of air from the ventilation of the mine for the purpose of feeding the boilers. It seems the result is, that in one of the boilers, according to the arrangement originally in use of using the return air for the boilers, you only require 2000 cubic feet of air for the boiler?

Mr. DAGLISH—At the outside.

The PRESIDENT—And that 7214 cubic feet is saved. The *return* air cools the boiler plates and boiler house, and the air direct from the downcast only goes through the fire?

Mr. DAGLISH—Yes.

The PRESIDENT—That is, 7214 cubic feet of return air cools the boiler, and a quantity equal only to 2000 feet, the first of the air, is taken underneath the bars to feed the fires? And that is sufficient to produce all the effects required, providing the boiler was worked with the fresh air entirely?

Mr. DAGLISH said it was so.

The PRESIDENT said, that would take 9214 cubic feet of air, which would thus be abstracted from the general ventilation of the colliery. By the plan of Messrs. Armstrong and Daglish, 2000 cubic feet only of the first of the air was carried under the bars, and produced the combustion required.

Mr. HUGH TAYLOR—Two-sevenths only of the quantity previously used.

Mr. DAGLISH said, it was two-ninths used, seven-ninths being saved.

Mr. HECKELS—Do I understand you rightly, that there is 7000 cubic feet of the return only required?

Mr. DAGLISH—Yes, all passing over the boiler to cool it in the return. The fresh air only is brought under the fire.

Mr. ATKINSON thought it was a very excellent plan, and a very great saving of air. The efficacy of the plan did not altogether depend upon the quantity of oxygen in the fresh air over that in the return air. He thought the way in which it operated was this:—In taking the fresh air direct from the downcast shaft, they got the full effect of the pressure, enabling it to be applied under the fire bars, so that they got extra combustion, in consequence of the extra blast. By this plan they got a greater amount of air inbye, and that was a good thing.

Mr. Heckels—I apprehend that the 2000 feet passing into the boiler fires would contract the air-way to the upcast.

Mr. Daglish—But how do you carry on combustion without doing so?

Mr. Heckels—You might have got the steam raised by the return air.

Mr. Daglish—No.

The President said, they would require some portion of air to keep up combustion. They used 9000 cubic feet altogether for the purpose of cooling the boilers, and keeping up the combustion. The cooling of the boilers did not require any pressure at all, and being the return air did not abstract from the ventilation. It was only the two-ninths that was used in the combustion that was abstracted.

Mr. Atkinson thought the plan would become very useful, as more boilers were introduced. He hoped, however, that shortly compressed air would do away with underground boilers.

Mr. Hugh Taylor inquired how far air could be compressed without losing its elasticity.

Mr. Atkinson said, that it had not been ascertained yet. He believed it had been compressed up to 200 and 300 atmospheres, and that was several thousand pounds to the square inch. The difficulty of working locomotives by compressed air consisted in this. You would have to increase the strength and weight of your reservoirs to carry the compressed air in, to such an extent that they would become too heavy, and it would become troublesome to have stations at short intervals to have them replenished.

The President said, that in Paris there were several engines worked by gunpowder.

Mr. Atkinson said, that would be as objectionable for underground purposes as steam.

The President said, that an engine of this description was exhibited in the International Exhibition in London.

Mr. Atkinson thought the fumes of gunpowder in mines would be rather objectionable.

The President—To a certain extent.

A paper "On Paradoxes in Ventilation," by Messrs. J. J. Atkinson and J. Daglish, then came on for discussion.

The President said, it was a very important paper, and, as a matter of form, he would ask whether Messrs. Atkinson and Daglish had any further explanations on the subject to communicate to the Institute before going into the discussion.

Mr. Atkinson—So far as I am concerned, I have nothing further to communicate.

The President presumed that every member present must have read the paper. The first part of it had been before them for a considerable time; the latter portion of the paper not so long, but still a sufficient time to enable any one of them to judge of the character of it, and, he supposed, to go into the details of each case. The only objection he took to it was the use of the word "paradox." He did not think that the cases mentioned in the paper were what were properly called "paradoxes."

Mr. Atkinson—A paradox is nothing contrary to the laws of nature. In physics a paradox was merely that which at first sight appeared to be so. I think the word is properly applied.

The President said, it seemed to be a practical illustration of the theory of the ventilation of mines, as explained by Mr. Atkinson in his paper (see Trans., Vol. III.). It contained cases in which that theory was carried into practice. They pointed out the defects in each of these cases, which, if not observed and allowed for, would produce a different result from what their theory of the mode of ventilation would produce. He thought that the whole system resolved itself into two or three paragraphs, which they had very properly gone into, in illustration of the general principles acted upon in all the cases. He (the President) then referred to page 120 of the paper in illustration of what he meant, which treated of descending ingoing currents, and then passed on to ascending outgoing currents of air, together with the resistance met with by the air circulating through the various splits. By observing correctly all the circumstances in each case, certain results are produced in ventilation; but if you omit to take into account any of the accelerating or diminishing forces, or of the amount of resistance, then you may have a different result from what you anticipate; and there are cases in your paper in which, when some of the resistances, or accelerating or diminishing forces, have not been accounted for, you have a different result than you ought to have, if all of these were accounted for, and possibly you might have a current going the reverse way, and hence a paradox, which is nothing more than an imperfectly considered case. It seemed to him that, by following out those principles of ventilation so ably set forth in the numerous papers by Mr. Atkinson "On Ventilation," that any adverse result in practice would be speedily detected. They very properly gave in the paper clear cases of failure, and the practical deductions therefrom. Those practical deductions showed that the failures all arose from not attending properly to all the elements of the forces exerted, and the resistances opposed to those forces, which, if not all attended to and accounted for, would produce an erroneous result. They enumerated those results in ten cases, he believed, and there could be no doubt that nothing could be more important than those illustrations in directing the attention, directly and practically, to all the elements constituting the forces exerted, and the resistances opposed to those forces in ventilation; and these illustrations enabled them to see that they had taken cognizance of all the circumstances relating to each case, to secure a correct result, and produce the desired amount of ventilation.

Mr. Atkinson—In the right direction.

The President—Just so. But if they omitted any of the resistances, as several of those cases showed they had done, then they might have a deficiency of accelerating force, and consequently a less quantity of air produced than they wanted in that particular current where the resistance might be greater than the force employed to produce it. These cases so brought before them were extremely important, in illustrating causes which had been brought into play in several peculiar and unexpected cases; and it rather seemed to him to be a sort of practical series of illustrations of the system of ventilation carried out in cases extremely instructive. He thought that young men, and even men a little older, would feel a great deal of interest in studying the several cases given in the paper. There was no doubt that there were several other cases in which the same results might occur, but he thought those mentioned were extremely important, more so than he had at first anticipated. He had read them and studied them attentively, and he would advise gentlemen to study each of them attentively, as they would find them extremely important. He himself had seen several of them in operation, and producing the results set forth in those illustrations. It would be impossible for the meeting, in a discussion of this kind, to go through them all, and to explain all their bearings, but they were put in a shape in the paper which seemed to him to be perfectly clear and explanatory. There was a case or two which he did not think was sufficiently attended to, and that was the splitting of the air, which was of the utmost importance in ventilation.

Mr. Heckels said, there was one thing that struck him about this case, and that was, that it would be too much to expect that a current would be as reliable as a steady current, when operated upon by two upcast shafts as it would be when only one was employed.

Mr. Daglish said, there was only one furnace in the case referred to, but there were two in some of the cases—No. 6 and No. 10.

Mr. Heckels—I am of opinion that if two furnaces be applied to the same current, it will be next to impossible to keep the current steady.

Mr. Daglish—No. 10 and No. 6 are instances of the action you speak of.

The President—If two furnaces are applied to one current of air, acting in opposing directions, of course the power of the furnaces varying constantly, there would be a constantly varying action.

Mr. Heckels said, that for that reason the current could not be kept steady, and therefore two upcast shafts became objectionable.

Mr. Daglish said, that on the contrary, they opposed that very strongly.

Mr. Heckels—Then, I suppose, you would split the downcast current?

Mr. Atkinson said, they would separate the two systems of ventilation, where practicable. A case had come under his notice lately, however, where he durst not recommend that they should be separated. In that case, in the event of the furnace of one of the upcast shafts being slack, and the other hard driven, the result would be to reverse the air in the return of one colliery and to bring it out in the return of the other colliery, but this would happen only under extreme conditions, which could be guarded against.

The President—In that case the two furnaces operate as one.

Mr. Atkinson said, at one of the collieries there are two furnaces, and only one at the other.

The President—Is the air connected in one current?

Mr. Atkinson said, the returns alone are connected, so that the two collieries exhausted as if from the general chamber out of the returns. The intakes of one colliery should not be connected with the returns of the other, but only with its intakes; and, similarly, the returns of either colliery should only be connected with the returns of the other, or it might be dangerous on a reversal taking place.

Mr. Heckels—Have you never found any of the return currents to reverse?

Mr. Atkinson said, there was a case of that where danger was occasioned by the return air passing from the return of one colliery into the intake of another, but this requires to be guarded against, and can only occur under extreme circumstances.

Mr. Heckels referred to a colliery where the upper part of the deep upcast shaft having been purposely allowed to become cool, it was afterwards discovered that the furnaces in the shallow upcast had drawn a portion of the heat from the deep upcast shaft, into the workings of the seam in which the furnaces of the shallow upcast were placed, and set fire to the coal.

Mr. Atkinson said, that when matters were in such an unusual state as that described by Mr. Heckels, where they made one furnace over hot and the other over cool, it was likely to reverse the air. But, under ordinary circumstances, there was very little, if any, more danger than they had to incur in the ordinary carrying on of a colliery every day. In the event of driving one furnace slack and the other hard, extra precautions should be taken.

Mr. Heckels said, it was to do away with the necessity of those precautions that they should aim at. He was apprehensive that where there was more than one shaft for the return, one of them would occasionally become a downcast, and the ventilation be destroyed.

Mr. Atkinson—Quite so; but there were circumstances where, instead of spending £80,000 in sinking a new shaft, it was desirable to connect two already in existence, taking due care to arrange the ventilation properly and provide against emergencies.

Mr. Berkley asked whether it would not be better to take a split and carry a part of that return separate and distinct to the other colliery, so that the two currents might not be pulled from one to the other.

Mr. Daglish—But sometimes it would not go. Instead of the return going from one colliery into the return of the other, it would not go, but come back.

Mr. Heckels—That is a result from having two upcast shafts.

Mr. Berkley—You should take one split right away from the neighbouring colliery into their returns.

Mr. Daglish said, it was so. He referred to illustration No. 6. There was a split went from the downcast D and passed direct into the return from the door X, passing from S to X up the upcast of that colliery. But under certain conditions a split came out of that return, passing in a reversed manner from the door Y, passing along those workings to get into the door Y. He should mention that this split went away at some intermediate point, and the return came out at that point [pointing to the place].

Mr. Berkley wished to ask Mr. Atkinson and Mr. Daglish if they had come to any conclusions or proposed any remedy in those cases ?

Mr. Atkinson said, he would refer him to Vol. III. of the Transactions of the Institute, where he would find very nearly what he knew upon this subject.

Mr. Daglish—We show that there should be no communication between the splits of different collieries, where practicable.

Mr. Atkinson—Mr. Berkley thinks we have not drawn any practical deductions or recommendations so as to avoid such things.

Mr. Berkley—Or to give the power of removing them.

Mr. Atkinson was firmly of opinion that he could go into a pit, and take all the things that Mr. Berkley had alluded to, by observations, within 5 or 10 per cent.

The President believed that all the cases illustrated were practical cases, which had existence in some place or other. It was true they did not give the names of the particular collieries, but they could do even that if necessary. He believed the members generally knew what collieries were alluded to. They were not theoretical conclusions at all ; they were practical conclusions resulting from the application of the present system of ventilation in some form or other.

Mr. M. Dunn said, he was once mixed up in a controversy upon two important points. One was the regulation of a door so as to be beneficial to the ventilation of the mine. Old viewers held that you could not make two furnaces, one close at hand and the other far off, work together. They went to Springwell, where they found one furnace on the other side of the brattice, and another far off, working comfortably together. They brought Mr. Heckels down to see what was doing at Springwell.

Mr. George Southern—But he came, unfortunately, when the furnace was out.

Mr. Heckels—It would not act.

Mr. Southern said, they were apprehensive of gas finding its way in by cracks to the Low Main return, and upon that account they put the Low Main furnaces out. This was done quite apart from the working of the furnaces, for the furnaces worked very well, but the separation of the air was a considerable distance away from the furnaces. It was not close at hand as in the case mentioned by Mr. Heckels, and that therefore made a considerable difference.

Mr. Dunn—That system is working yet at Springwell.

Mr. Berkley said, to a certain extent it was.

Mr. Heckels said, that the master wasteman at Springwell told him, at the time he was there, that the system referred to would not act.

Mr. Southern was quite sure the master wasteman would not mean to say that the system would not act, as the furnace was put out for the reason he had already stated.

Mr. Heckels—Well, he said, he could not keep the currents steady.

Mr. Berkley said, it acted there to a certain extent yet, but the furnace was not in.

The President said, the conclusion he had come to when at Springwell and at Houghton pits, was, that it was unsafe ventilation to make it dependent on the action of two separate and distinct furnaces, and operated upon by currents having a connection with each other. He was satisfied, in his own mind, that it was not a prudent course to pursue.

Mr. Atkinson said, he did not approve of it where it could be avoided.

Mr. Southern said, the cases would bear further discussion.

Mr. Daglish suggested that the cases should be taken *seriatim*, so that the members who had anything to say could do so, and bring forward further cases, because they got off from one case to another by taking them in this irregular way. There was no doubt there were several similar cases within the knowledge of the members.

The President said, the matter was very important, and he thought it possible they might have time to discuss the several cases *seriatim* during the summer months. The discussion was accordingly adjourned.

The following resolution was then passed: — That the following parties who read papers before the British Association, be applied to to furnish copies of such papers and plans, for insertion in the Proceedings of the Institute, viz.:—

On the Magnesian Limestone of the County of Durham, by Messrs. J. Daglish and G. B. Forster, M.A.;

On the Minerals and Salts in Coal Pits, by Messrs. John Daglish and R. C. Clapham;

On the Discovery of the Rock Salt Deposit in Cleveland, by Mr. John Marley;

On the Team Wash, by the President and Mr. E. F. Boyd;

On the Manufacture of Iron in connection with the Northumberland and Durham Coal-fields, by Mr. I. L. Bell;

On the Coal and Red Sandstone of Cumberland, by Mr. M. Dunn;

On the Geology of Weardale, by Mr. Sopwith.

The meeting then adjourned.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, SATURDAY, NOV. 7, 1863, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-ON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

The minutes of the Council having been read, thanks were voted to Mr. Sopwith for a model of a safety-cage which he had seen working near Aix-la-Chapelle.

The following gentlemen were elected members of the Institute :—Mr. James A. Maughan (graduate), Towneley Colliery, Ryton, Newcastle; Mr. Wm. Firth, Burley Wood, Leeds; Mr. Robert Mallet, C.E., F.R S., London; Mr. Marshall Nicholson, West Ardsley Colliery, Wakefield; Mr. James McMurtrie, Radstock Colliery, Bath; Mr. Isaac Fletcher, Clifton Colliery, Workington; and Mr. William O. Wood, Brancepeth Colliery, Durham.

Mr. Atkinson said, that Mons. Guibal wrote on the 16th of October on behalf of a society in Belgium, offering to exchange Proceedings with the Institute.

The President said, the Council had already attended to that subject, and had agreed to exchange Proceedings. The only part of the minutes of the Council which it was necessary to bring before the general meeting, had reference to a paper on Coal Mining, which was being published by Mr. Reid, and they would have to consider how far it would interfere with the publication of the Proceedings of the Institute, and how far it would be proper to permit such a publication. The party promoting the publication of the paper consisted of the Mayor of Newcastle, Sir Wm. Armstrong, Mr. John Taylor, and Dr. Richardson, with whom the Council had had an interview. The Council told them, if they admitted the right of the Institute to the copyright of the paper, and if they asked leave of the Council to print it, they might do so. To this they consented. He had now to ask, as a matter of form, that the proceedings of the Council be confirmed.

Confirmed accordingly, and permission to print the paper granted.

Mr. John Marley's paper "On Rock Salt at Middlesbro'," and Mr. I. L. Bell's paper "On the Manufacture of Iron in connexion with the Northumberland and Durham Coal-fields," which were read at the Meeting of the British Association, were taken as read before the Institute, in order that they might be incorporated with the proceedings.

The PRESIDENT said, the next business was the adjourned discussion on Messrs. Atkinson and Daglish's paper "On Paradoxes in Ventilation." Messrs. Heckels and Berkley had promised a paper on one or two points raised at the previous discussion, but he did not see those gentlemen present.

The SECRETARY—They promised to adduce some new cases.

The PRESIDENT said, the question was whether they should go on with the adjourned discussion or not.

Mr. DAGLISH said, he had nothing farther to say on the subject, but he would be glad to hear if any one else had any fresh cases, or any objections to offer on what had been advanced.

Mr. BOYD said, he had one case to bring before the Institute, but he would require a black board to describe it. It was distinct from any of the cases which they had hitherto considered.

The PRESIDENT said, that if it was a new case, Mr. Boyd should furnish them with a paper on the subject.

Mr. BOYD said, he had not considered it of sufficient importance for a paper. It elucidated the question, showing the number of difficulties they had to contend with. If it was required to be written, he would prepare a paper upon it.

The PRESIDENT said, Mr. Green had a paper entitled "Notes on the Anthracite Coal Region of North America." Mr. Green had not sent the paper in time to be announced in the circular, but if the Society wished to have it read it might now be read. The only remark he had to make was, that according to the new rules, although a paper might be read the printing of that paper and the publication of the plates accompanying it, rested with the Council. The printing of the plates, in some cases, caused an expense beyond what the paper warranted. The state of their funds required that they should enforce economy, without any intention, however, to curtailing the efficiency of the Transactions.

Mr. Green read his paper.

The PRESIDENT said, Mr. Green might assume that the paper would be printed, with such of the plates as would be required to elucidate it.

The meeting then separated.

ON

THE DISCOVERY OF ROCK-SALT

IN THE

NEW RED SANDSTONE AT MIDDLESBROUGH.

By JOHN MARLEY.

At the solicitation of the President of the Geological Section, and in order to furnish the excursionists to Cleveland with the fullest information, I had the honour to lay before the members of the British Association a short sketch of the second great discovery in Cleveland, viz., that of rock-salt at Middlesbrough. Messrs. Bolckow and Vaughan, the gentlemen who have proved the existence of this salt, were the first to commence iron works at Middlesbrough, 23 years ago; they were also the first to make a practical application of the discovery of the Cleveland ironstone, 15 years ago, and opened their Eston ironstone mines, near Middlesbrough, 13 years ago. They have since that time vended about six million tons of ironstone from this locality. And now, in 1863, they have the honour, and I trust they may also have the profit, of the discovery of salt in that district.*

The fresh water requirements of Messrs. Bolckow and Vaughan, in connection with their iron works at Middlesbrough, being very large, they commenced, about four years ago, to sink a well or shaft for fresh water; and, as will be seen by the large coloured section exhibited, the shaft was carried to the depth of 180 feet; but owing to the top-feeders being in connection with the flow of the tide in the river Tees, and consequently brackish, they were tubbed back with metal tubbing, and the others being fresh water feeders, were tubbed back and arranged with sluices so as to be available when required. The supply of fresh

* Specimens of this salt, and also a small piece of the new-red-sandstone overlying the same, were exhibited to the Section.

water being still not considered sufficient, a very large bore-hole was, about a year ago, commenced from the bottom of the shaft, at the depth stated, under the direction of Mr. S. C. Homersham, C.E., of London, and the immediate superintendence of Mr. Samuel Godfrey, mechanical engineer to the Middlesbrough Iron Works; and with the excellent boring machinery of Messrs. Mather and Platt, of the Salford Iron Works, Manchester, which is worked by steam and flat wire rope. A bore of 18 inches diameter has been put down to the present extreme depth of 1312 feet. In going through the red-sandstone, the maximum rate attained was 13 feet in 13 hours, or one foot per hour; and even when upwards of 1100 feet deep a rate of 3¼ feet per 13 hours, or 3 inches per hour, was attained. The machinery and apparatus, which are well worthy of inspection, being of first-class mechanism and utility for holes of large diameter and great depth, were viewed with great interest by those gentlemen who visited Cleveland. The details of the nature of the strata bored through will be seen by examination of the section. These beds form part of the Upper-new-red-sandstone or Trias formation, the same, I need scarcely say, as those in which the deposits of rock-salt of Cheshire occur. The rock-salt was first pierced at a depth of 1206 feet, and has been found to form a bed 99 feet in thickness. This bed terminates in a sort of conglomerate, consisting apparently of salt and limestone mixed together.

The quantity and quality of the brine has not yet been fully tested, but I have obtained the following analysis of a sample from the very light coloured portion of the bed No. 50:—

	Per Cent.
Chloride of Sodium	96·63
Sulphate of Lime...	3·09
Sulphate of Magnesia	0·08
Sulphate of Soda...	0·10
Silica	0·06
Oxide of Iron	trace
Moisture	0·04
	100·00

It is as yet impossible to estimate the extent or area of this deposit. On the north we have, at Castle Eden Colliery, the coal measures overlaid by the Permian; and at Oughton Colliery boring, nearer to the Tees, the Trias, has been bored into about 500 feet; the Hutton coal seam, at Castle Eden Colliery, being about 750 feet below the sea level, and the

NOTE.—A drawing of the machinery is appended for the study of Mining Engineers.

salt at Middlesbrough about 1250 feet. On the south side of the Tees the Lower-lias is soon met with and capped by the Upper-lias and Oolitic measures. These measures dip both to the south and north from the Tees.

The following is an account of the strata sunk and bored through. The sinking was commenced on July 4, 1859:—

No.		Fm.	Ft.	In.
1.	Made ground (slag, chalk, &c.)	1	5	0
2.	Dry slime or river mud	1	2	0
3.	Sand with water	1	4	0
4.	Hard clay (dry)	1	4	0
5.	Red sand with a little water	0	1	0
6.	Loamy sand with a little water	0	3	0
7.	Hard clay (dry)	2	3	0
8.	Rock, mixed with clay and water	1	5	0
9.	Rock, mixed with clay (dry)	0	1	0
10.	Rock, mixed with gypsum (dry)...	1	0	0
11	Gypsum with water	0	2	0
12.	Red sandstone with small veins of gypsum and water	9	1	0
13.	Gypsum rock (dry)	1	0	0
14.	Brown shale with water	0	1	0
15.	Red sandstone	0	4	0
16.	do. with small veins of gypsum and water	2	0	0
17.	Blue post stone with water at bottom	0	3	0
18.	Red sandstone with water	3	1	0
	Bottom of sinking	29	4	0
19.	Red sandstone	72	5	4
20.	Red and white sandstone...	0	1	6
21.	Red sandstone	35	5	7
22.	do. and clay	0	1	0
23.	Red sandstone	8	4	3
24.	do. and clay	1	3	0
25.	do.	11	0	5
26.	Strong clay	0	2	9
27.	Red sandstone and clay	0	1	6
28.	do.	4	3	5
29.	do. and clay	1	3	0
30.	do. with a vein of blue rock 1¼ thick at 1005 feet...	8	1	4
31.	Red and blue sandstone	0	1	5
32.	Red sandstone	1	0	0
33.	do. and thin veins of gypsum	0	1	5
34.	do. do.	6	3	8
35.	Red sandstone, blue clay, and gypsum	0	1	2
	Carried forward	183	2	9

	Brought forward	183	2	9
36.	do. with veins of gypsum	14	3	3
37.	Gypsum	0	3	2
38.	White stone	0	0	8
39	Limestone	0	2	8
40	Blue rock	0	0	2
41.	Blue clay	0	0	2
42	Hard blue and red rock	0	0	10
43	White stone...	0	2	7
44.	Dark red rock	0	1	2
45.	Dark red rock, rather salt	0	6	7
46.	Salt rock, rather dark (1)...	2	0	7
47.	do. very dark (2)...	0	4	1
48.	do. very light (3)...	0	3	6
49.	do. rather dark (4)...	4	3	4
50.	do. very light (5)...	7	1	6
51.	do rather light (6)...	1	3	0
52.	Limestone	0	1	0
53.	Conglomerate. This rock resembles limestone, and contains a great quantity of salt	1	0	4
	Total	218	5	4

After reading the above communication to the section, Mr. Marley remarked, that he thought it premature to speculate upon the beneficial effects of the discovery which the paper described, or as to its bearing upon the possibility of there being coal under the Lias in Cleveland; but as Sir William Armstrong had recommended that inquiry should be made into the extent of the present coal seams, he would observe, that it might possibly be of more importance to direct attention to unproved districts.

Mr. Pattinson, analytical chemist, said, that the importance of the discovery of this rock-salt at Middlesbrough, would be appreciated when it was stated that the Newcastle district consumed annually 100,000 tons of salt, which is chiefly obtained from the Cheshire district. The alkali manufactures of this country existed in two districts—those of Lancashire and the Tyne. The manufacturers of Lancashire had a great advantage in the Cheshire salt being so near at hand; but this discovery at Middlesbrough would give the Tyne manufacturers a decided advantage. Another advantage also would be gained. There was a large quantity of heat wasted at present—one-third of the coal was wasted in producing coke; and in the iron manufacture a large quantity of heat was wasted in the blast, puddling, and other furnaces. Great economy might be effected by evaporating the brine, which he hoped would be pumped from this bed of rock salt, with waste heat from coke ovens, the loss of which had been so long lamented by every one anxious about the coal of the district.

Mr. C. Moore knew of nothing to compare in interest and importance with this discovery of rock salt in those beds of the middle Trias. It showed that in this part of the country many beds, which should come between the beds of the ironstone and those of the Trias, in which the rock-salt was found, must be absent. With reference to the exhaustion of coal, his view was that we should get coal in districts of which we had very little conception, and that an accidental circumstance would some day show that we had extensive coal-measures of which we had no idea now. A curious circumstance had arisen in connection with ironstone which showed the dying out of certain strata and the coming in of others where they were least expected. In some remarks he had made, with reference to the ironstone which Mr. Marley had alluded to, as being above the rock-salt, he had noticed a remarkable section which occurred to the south of Frome. The equivalent of that ironstone, which occurred over a large area in the West of England, had never been recognized in the neighbourhood of that part of Somerset; but a friend had sent him black stones, containing fossils, which showed him that without doubt, the beds were the equivalent of the Cleveland ironstone. The curious fact he wished now to allude to was that in Somersetshire, passing under the ironstone, they came at once down on the coal-measures. It was very strange that there they had strata so close together of so much importance, and here they went through the ironstone to the rock-salt, where they had least expected it. It might be that they would come to coal-measures under the ironstone in the Middlesbrough district.

Mr. James Stevenson said, that if the analysis that had been made of the rock-salt was borne out on a large scale, he thought our alkali makers would be able to use it without refining it. Cheshire rock salt could hardly be used on account of the great quantity of the iron and slag it contained. The impurities in a sample from Middlesbrough consisted only of sulphate of lime.

Mr. Pattinson said, that the sample he analysed was purer than the samples on the table, but he did not select the sample; this now produced seemed to contain more oxide of iron.

Mr Marley observed, in answer to Mr. Pattinson, that the specimens exhibited were from all the various coloured beds, but the sample analysed by Mr. Pattinson was from No. 5 bed only. He also corrected

Mr. Moore as to the position of the rock-salt and ironstone, the latter not being passed through in getting to the rock-salt.

The following description of the boring-machine used at Middlesbrough, is extracted from a paper by Mr. Colin Mather, published in the "Journal of the Society of Arts," June 1, 1855.

"The construction of the boring head and shell pump, and the mode of acquiring the percussive motion, constitute the chief novelties of the system and machine. The couple-cylinder engine, with the reversing or link motion, is used for winding and lowering the apparatus, but an ordinary winding engine, similar to those used in collieries, may be applied."

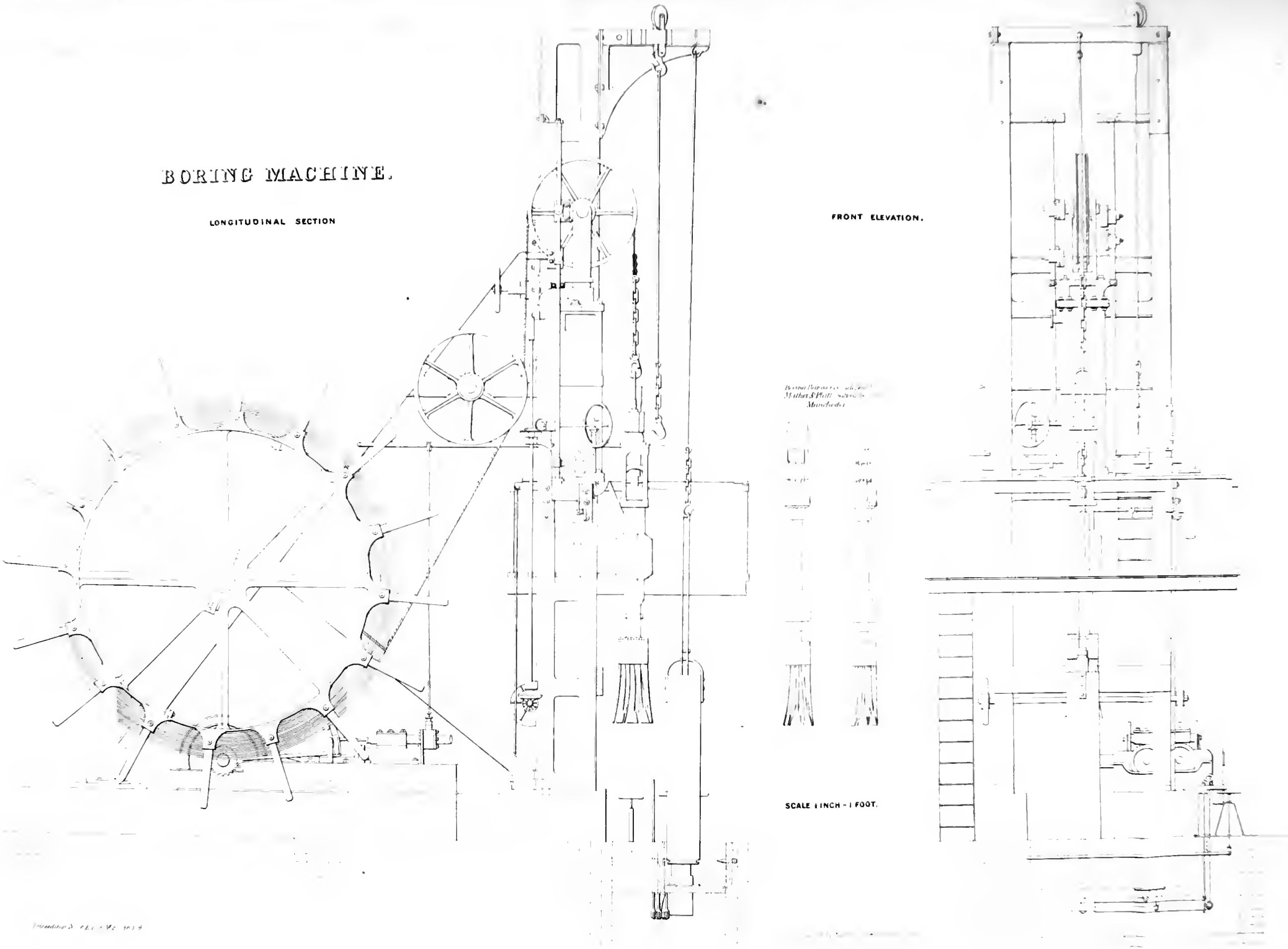
"The boring head consists of a wrought-iron bar, about 8 feet long, on the lower part of which is fitted a block of cast iron, in which the chisels or cutters are firmly secured. Above the chisels an iron casting is fixed to the bar, by which the boring-head is kept steady and perpendicular in the hole. A mechanical arrangement is provided, by which the boring-head is compelled to move round a part of a revolution at each stroke. The loop or link by which the boring apparatus is attached to the rope is secured to a loose casting on the wrought-iron bar, with liberty to move up and down about six inches. A part of this casting is of square section, but twisted about one-fourth of the circumference. This twisted part moves through a socket of corresponding form on the upper part of a box, in which is placed a series of ratchets and catches, by which the rotary motion is produced. Two objects are here accomplished—one the rotary motion given to the boring-head, the other a facility for the rope to descend after the boring-head has struck, and so prevent any slack taking place, which would cause the rope to dangle against the side of the hole, and become seriously injured by chafing."

"The shell-pump is a cylinder of cast-iron, to the top of which is attached a wrought-iron guide. The cylinder is fitted with a bucket similar to that of a common lifting pump, with an india-rubber valve. At the bottom of the cylinder is a clack, which also acts on the same principle as that in a common lifting-pump, but it is slightly modified to suit the particular purpose to which it is here applied. The bottom clack is not fastened to the cylinder, but works in a frame attached to a rod which passes through the bucket, and through a wrought-iron guide at the top of the cylinder, and is kept in its place by a cotter, which passes through a proper slot at the top of the rod. The pump-rod, or that by which the bucket is worked, is made of a forked form, for the two-fold purpose of allowing the rod to which the bottom clack is attached to pass through the bucket, and also to serve as the link or loop by which the whole is suspended."

"The wrought-iron guide is secured to the top of the cylinder, and prevents the bucket from being drawn out when the whole is so suspended. The bottom clack also is so arranged that it is at liberty to rise about six inches from its seating, so as to allow large fragments of rock, or other material, to have free access to the interior of the cylinder when a partial vacuum is formed there by the up-stroke of the pump."

"The percussive motion is produced by means of a steam cylinder, which is fitted with a piston of 15 inches diameter, having a rod of cast-iron 7 inches square, branching off to a fork, in which is a pulley of about three feet in diameter, of

BORING MACHINE.



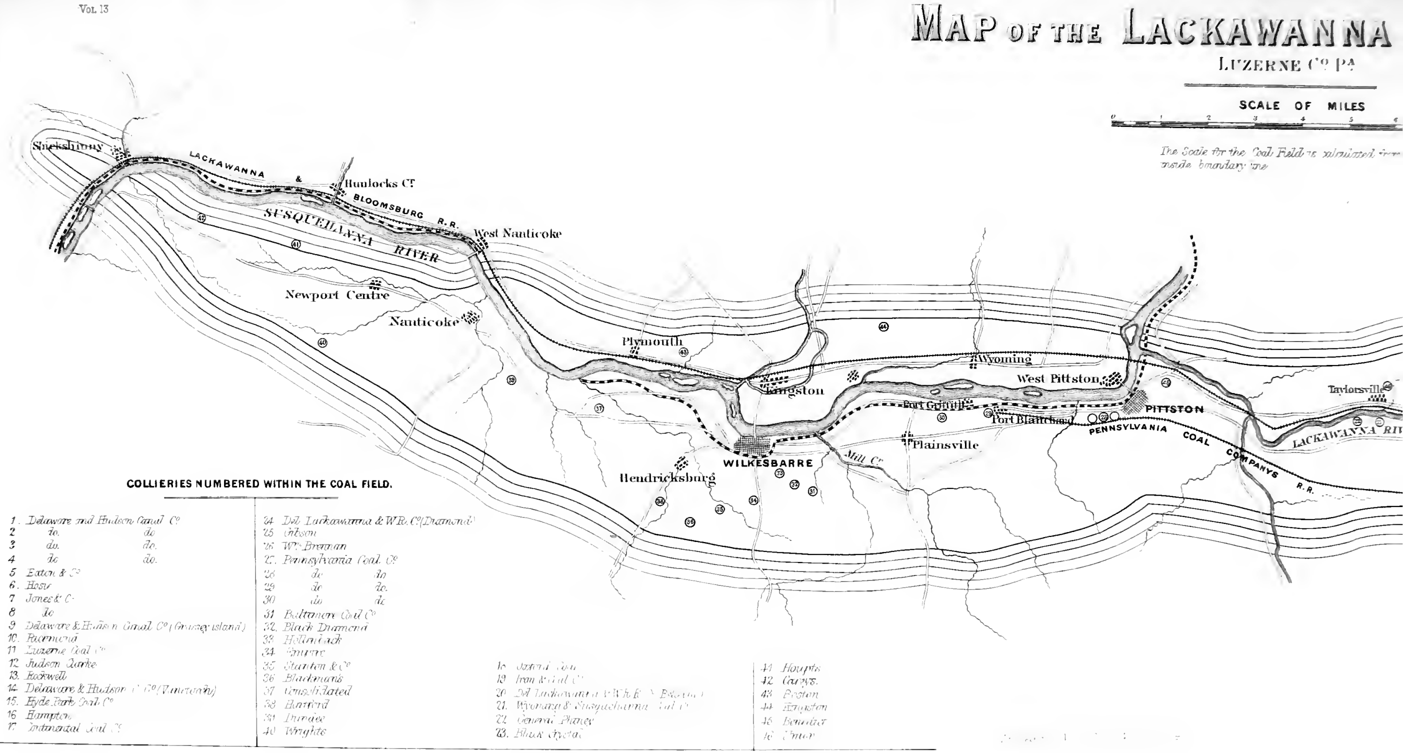
sufficient breadth for the rope to pass over, and with flanges to keep it in its place. As the boring head and piston will both fall by their own weight when the steam is shut off, and the exhaust-valve opened, the steam is admitted only at the bottom of the cylinder; the exhaust-port is a few inches higher than the steam-port, so that there is always an elastic cushion of steam of that thickness for the piston to fall upon."

"The valves are opened and shut by a self-acting motion derived from the action of the piston itself, and as it is of course necessary that motion should be given to it before such a result can ensue, a small jet of steam is allowed to be constantly blowing into the bottom of the cylinder; this causes the piston to move slowly at first, so as to take up the rope, and allow it to receive the weight of the boring-rod by degrees, and without a jerk. An arm which is attached to the piston-rod then comes in contact with a clam, which opens the steam-valve, and the piston moves quickly to the top of the stroke. Another clam, worked by the same arm, then shuts off the steam, and the exhaust-valve is opened by a corresponding arrangement on the other side of the piston rod. By moving the clams the length of the stroke can be varied at the will of the operator, according to the material to be bored through. The fall of the boring-head and piston can also be regulated by a weighted valve on the exhaust-pipe, so as to descend slowly or quickly, as may be required."

"The general arrangement of the new machine may be described as follows:— The winding drum is 10 feet in diameter, and is capable of holding 3000 feet of rope, 4½ inches broad and half an inch thick; from the drum the rope passes under a guide pulley, through a clam, and over the pulley which is supported on the fork end of the piston rod, and so to the end which receives the boring-head, which being hooked on and lowered to the bottom, the rope is gripped by the clam. A small jet of steam is then turned on, causing the piston to rise slowly until the arm moves the clam, and gives the full charge of steam; an accelerated motion is then given to the piston, raising the boring-head the required height, when the steam is shut off, and the exhaust opened in the way described, thus effecting one stroke of the boring-head as regulated by a back pressure valve in the exhaust pipe. The exhaust port is six inches from the bottom of the cylinder; when the piston descends to this point it rests on a cushion of steam, which prevents any concussion. To increase the lift of the boring-head, or compensate for the elasticity of the rope, which is found to be one inch in one hundred feet, it is simply necessary to raise the clams on the clam shaft whilst the percussive motion is in operation. The clam which grips the rope is fixed to a slide and screw, by which means the rope can be given out as required. When this operation is completed, and the strata cut up by a succession of strokes thus effected, the steam is shut off from the percussive cylinder, the rope unclamped, the winding engine put in motion, and the boring-head brought up and slung from an overhead suspension bar by a hook fitted with a roller to traverse the bar. The shell-pump is then lowered, the *debris* pumped into it, by lowering and raising the bucket about three times, which the reversing motion of the winding engine readily admits of; it is then brought to the surface and emptied by the following very simple arrangement. At a point in the suspension bar a hook is fixed perpendicularly over a small table in the waste tank, which table is raised and

and lowered by a screw. The pump being suspended from the hook hangs directly over the table, which is then raised by the screw till it receives the weight of the pump. A cotter, which keeps the clack in its place, is then knocked out, and the table screwed down. The bottom clack and the frame descending with it, the contents of the pump are washed out by the rush of water contained in the pump cylinder. The table is again raised by the screw, and the clack resumes its proper position; the cotter is then driven into the slot, aud the pump is again ready to be lowered into the hole as before. It is generally necessary for the pump to descend three times, in order to remove all the *debris* broken up by the boring-head at one operation."

"The following facts obtained from the use of the machine in boring in the new-red-sandstone at Manchester, will show its actual performance, and enable us to compare it with the other systems mentioned in this paper. The boring-head is lowered at the rate of 500 feet a minute; the percussive motion is performed at the rate of 24 blows a minute, and being continued for ten minutes, the cutters in that time penetrate from 5 to 6 inches; it is then wound up at 300 feet a minute. The shell-pump is then lowered at the rate of 500 feet a minute, the pumping continued for one minute and a half, and being charged, the pump is wound up at 300 feet a minute. It is then emptied and the operation repeated, which can be accomplished three times in 10 minutes, at a depth of 200 feet. The whole of one operation, resulting in the deepening of the hole 5 to 6 inches, and cleansing it of *debris* ready for the cutters or boring-head being again introduced, is seen to occupy an interval of 20 minutes only. The value of these facts will be best shown by comparing them with the results by the old method."

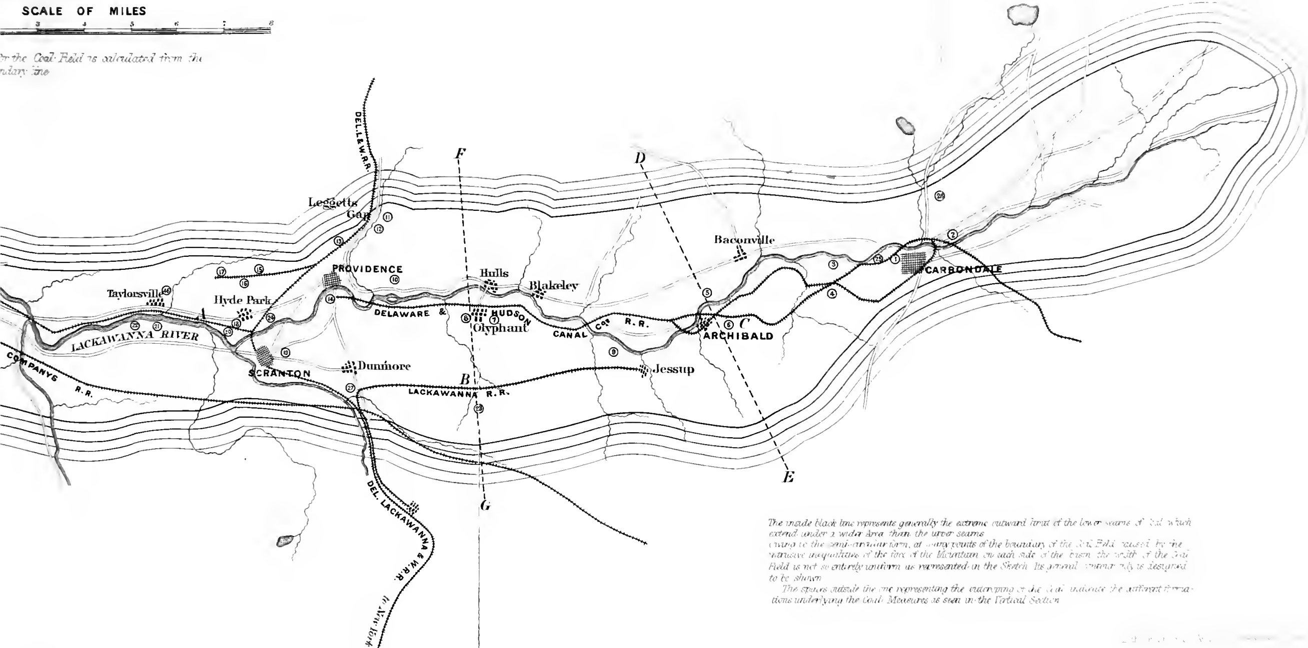

MAP OF THE LACKAWANNA
LUZERNE Cº Pᴬ
SCALE OF MILES
Shickshinny
LACKAWANNA & BLOOMSBURG R.R.
Hunlocks Cᵏ
SUSQUEHANNA RIVER
West Nanticoke
Newport Centre
Nanticoke
Plymouth
Kingston
Wyoming
West Pittston
Taylorsville
PITTSTON
Port Griffith
Port Blanchard
PENNSYLVANIA COAL COMPANYS R.R.
LACKAWANNA RIV
Plainsville
Mill Cᵏ
WILKESBARRE
Hendricksburg
COLLIERIES NUMBERED WITHIN THE COAL FIELD.
1. Delaware and Hudson Canal Cº
2 do. do
3 do. do.
4 do do.
5 Eaton & Cº
6. Hoss
7 Jones & Cº
8 do
9 Delaware & Hudson Canal Cº (Grassy island)
10. Richmond
11 Luzerne Coal Cº
12 Judson Clarke
13. Rockwell
14 Delaware & Hudson C. Cº (Vanstorch)
15. Hyde Park Coal Cº
16 Hampton
24 Del. Lackawanna & W.R. Cº (Diamond)
25 Gibson
26 Wᵐ Brennan
27. Pennsylvania Coal Cº
28 do do
29 do do.
30 do do
31 Baltimore Coal Cº
32. Black Diamond
33 Hollenback
35 Stanton & Cº
36 Blackman's
37 Consolidated
38 Hartford
39 Dundee
40 Wrights
23. Black Crystal
41 Houpts
42 Careys.
43 Boston
44 Kingston
45 Bennetts

...KAWANNA COAL FIELD

...LUZERNE Co. Pa.

SCALE OF MILES

...r the Coal Field is calculated from the ...ndary line



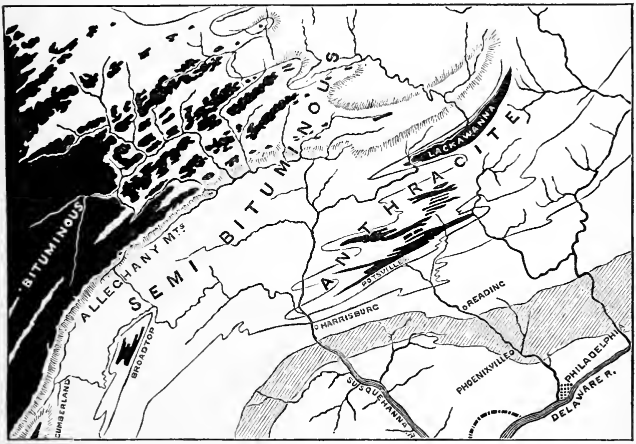
NOTES

ON THE

ANTHRACITE COAL REGION IN NORTH AMERICA.

By WILLIAM GREEN, Jun.

Having recently visited the Anthracite Coal-region in Pennsylvania, North America, a short account of the district may not be uninteresting to the members of the Institute.



Map showing the relation of the Anthracite Coal region to the great Appalachian Coal-field, according to Leslie.

This coal-field is found in several detached portions, separated by ranges of hills, and is divided into three groups, viz. :—

* The Schuylkill, containing....164	sq. miles,	or 104,960	acres.
Mahanoy and Shamokin, do...115	do.	or 73,600	,,
Wyoming, do...............118	do.	or 75,520	,,

These groups are again broken up into several basins, especially the two former.

* R. C. Taylor, Author of the Statistics of Coal Produced and Consumed in America.

The district to which my attention was particularly directed was in the Lackawanna valley, near Archbald, in the Wyoming coal-field (see accompanying plan and map); its distance from New York is about 130 miles, in a north-westerly direction.

The length of the Wyoming coal-field is about 45 miles, and its breadth from two to five miles. Though subject to strong undulations, it is singularly free from dykes and dislocations.

The horizontal and vertical sections appended, though not perhaps strictly accurate as to the comparative thickness of the various strata, are sufficiently so to give a very good idea of the general stratification of the district.

At Wilkesbarre, in the lower part of the valley, according to Professor H. D. Rogers, there are from 1000 to 1200 feet of coal-bearing strata, including 16 or 18 separate beds of coal. He estimates the coal-measures near Scranton to be 700 feet thick, containing 12 seams of coal of an aggregate thickness of 74 feet, of which 39 or 40 feet are available for market.

These seams vary from one to eighteen feet in thickness; the lowest in the series, by referring to the accompanying section, will be seen to rest closely upon a conglomerate, which again rests upon the Old-red-sandstone or Devonian formation.

Immediately above the seams and forming the roof, will be found, almost universally, a micaceous sandstone; the presence, or cropping out, of this stone on the surface is, therefore, a pretty sure indication of there being coal underneath. The thill of many of the seams, especially of those lowest in the series, is clay filled with Stigmaria.

In the slaty shale above the coal, are found numerous beautiful impressions of Sigillaria, Lepidodendron, and other fossil plants; one impression I measured, covered a slab six feet long by four feet in width.

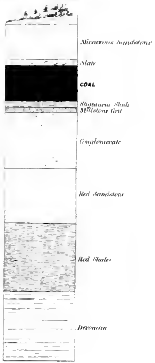
The seams generally lie very regular, but, owing to the undulations previously named, the rise and dip is by no means uniform throughout.

At Dunmore mines, the rise is from 2in. to 3in. per yard, S. 50 E.

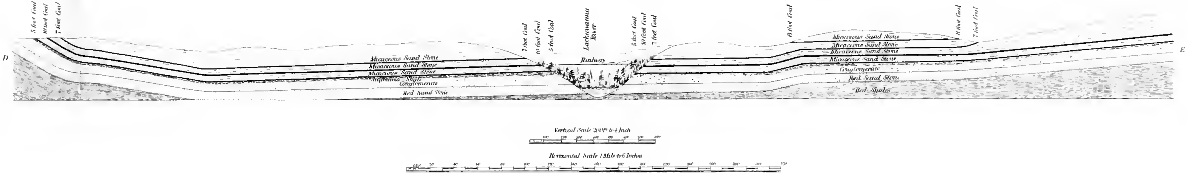
Near Archbald „ „ „ N. 80 E.

The quality of the different seams does not essentially vary, with the exception of the seven-feet seam (see section), a specimen of which I produce. The produce of this vein is considered to be of superior quality, especially in the manufacture of steel.

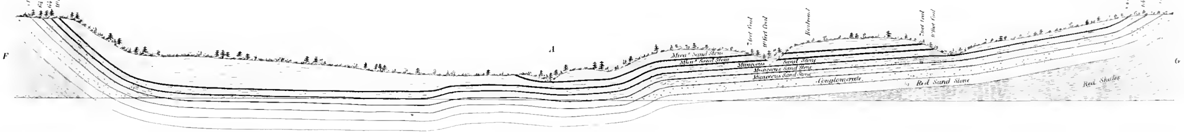
The analysis of this coal, by Abraham Gesner, analytic chemist, is as follows:—



TRANSVERSE SECTION OF THE LACKAWANNA COAL FIELD AT ARCHIBALD, LUZERNE COUNTY, PENNSYLVANIA, FROM D TO E NEAR ARCHIBALD SHOWING MORE PARTICULARLY THE POSITION OF THE COAL IN THE PROPERTY IN THE WARRANTEE NAMES OF ELIZABETH KELLOGG, OLIVE SMITH, JOHN CLARK &c. ON THE EAST SIDE OF THE LACKAWANNA RIVER.



TRANSVERSE SECTION OF THE LACKAWANNA VALLEY IN BLAKLEY TOWNSHIP, LUZERNE COUNTY, PENNSYLVANIA. JOHN PEARCE & DAVID LEWIS TRACTS OF COAL-LAND.



Carbon	94·10
Volatile matter, Hyd., Nit., and Oxygen ...	3·62
Ash	2·28
	100·00

This coal is bright and glossy, with a semi-metallic lustre, clean, and free from smut; it produces a very strong heat, and is durable in the grate or furnace.

The coals from the lower seams are vended for domestic and manufacturing purposes; in the house-grates they produce no smoke, and are very hot and lasting, leaving, according to some authorities, 7 per cent. of white ash.

The general analysis of the lower seams, under the name of Scranton coal, is stated by Professor Rogers to be—

Carbon	88·98
Volatile matter	6·36
Ash	4·66
	100·00

A curious feature respecting the preparation of Anthracite coal for market, is the breaking it into a variety of sizes, known by different names, by means of a huge and costly machine called a breaker, more properly a crusher.

This machine consists of two iron cylinders, about three feet long and sixteen inches in diameter, placed in a horizontal position, parallel to each other, and about ten inches apart; each cylinder having iron teeth, about four inches long and about the same distance apart.

The coal is dropped between these cylinders, which revolve towards each other at the rate of 200 or 300 revolutions per minute, as a coal-owner, from whom I quote, says, "breaking, crumbling, smashing, and grinding the coal in a truly horrible manner."

From 400 to 500 tons per day are passed through these machines according to their size. Their cost is from 15,000 dollars and upwards, and forms a serious item in the cost and expenses of a colliery.

The waste caused by them is enormous, varying from 15 to 35·20 per cent., according to the description of machine used, Battins being the most wasteful.

The coal, when broken, is passed through a revolving screen from 24 to 27 feet long, divided into lengths, each length having a different-sized mesh to separate the coals.

The names of these prepared coals are—

Broken, or grate,	passed	through a	$2\frac{1}{2}$	inch mesh.
Egg	„	„	$2\frac{1}{4}$	„
Stove	„	„	$1\frac{3}{4}$	„
Nut	„	„	$1\frac{1}{16}$ & 1	„
Chestnut	„	„	$\frac{3}{4}$	„
Pea	„	„	$\frac{1}{2}$	„

The per centage of these various sizes at the Delaware and Hudson Canal Co's Mines, near Archbald, was stated by the Chairman as—

	Per Cent.
Broken	28·61
Egg	10·87
Stove	31·71
Nut	9 05
Pea and waste	19·76
	100 00

When 40 per cent. was sold at an adjoining mine, unbroken, as furnace and steam coal, the per centage was as follows:—

Furnace and steam, unbroken	40·0
Egg	15·0
Stove	15 0
Chestnut...	20·0
Small and waste	10·0
	100 0

The selling prices of these various sizes of coal at the mines, before the disturbance in the currency caused by the war, was—

Furnace lumps, unbroken ...	80 cents per ton.
Steam „ „ ...	83 „
Grate	90 „
Egg	105 „
Stove	125 „
Chestnut	50 „

The specific gravity of the Lackawanna coal is stated to be 1·404; in calculating the produce per acre, 1600 tons per foot is the usual data taken.

Taylor assumes the mean weight of American anthracite to be 2601 lbs. per cubic yard, whereas European anthracite, he states, is only 2281 lbs.

The hardness and durability of this coal is very great; some from the ten feet seam, which I inspected, had been laid out and exposed to the weather for three or four years, without having suffered any apparent alteration or injury.

In the Wyoming valley there are about thirty collieries; those in the upper part of it being, for the most part, wrought by level or slope drifts, while those in the lower portion are worked by shafts, the deepest of which are now only exceeding 1200 feet. The average cost of the present mines above water level, may be taken at £5800, while those below water level have averaged at £11,900.

Collieries working by levels are rapidly brought into full operation. Oliphant Colliery yielded 85,000 tons the first year. Though the general average for collieries won by shafts appears low, yet a few have had from £20,000 to £30,000 expended upon them.

The daily output of the collieries range from 300 to 500 tons, some having a capability of 800 tons.

In some of the mines a considerable quantity of water is met with. At the Delaware and Hudson Canal Co.'s mines, at Carbondale, not less than 20,000 tons in the 24 hours, pumped for the most part by water wheels, working 12 sets of 12-inch pumps.

The value of good coal lands, including the surface, is from 250 dollars to 300 dollars per acre, and being above or below water level making a material difference. The rent of coal also varies materially for the same reason; from nine to sixteen or eighteen cents per ton includes the two extremes.

Owing to six or eight weeks holiday about Christmas, and the closing of the navigation for four or five months in winter, those collieries dependent upon the Delaware and Hudson Canal Company, and Pennsylvania Coal Company, only work about 240 days per annum. The above Companies, with the Lackawanna and Western Railroad Company, have a practical monopoly of a great part of the valley, the coals being purchased by them either at or near the collieries. The bulk of the coals are sent to the New York market, where they are now realizing eight dollars and upwards per ton in the retail yards; whereas, in ordinary times, the selling price is from four dollars to five dollars per ton; but it must be borne in mind that the present price is in paper currency.

					Tons.
The Vend from the Wyoming	coal-field	in	1861,	was	2,807,385
Do.	do.	do.	1862,	„	2,971,713

The ordinary increase in the last two or three years has fallen short, in consequence of the scarcity of labour caused by the draughting of men to the war, strikes, and failure of the canals from extraordinary freshets.

The great north-eastern outlet for the Lackawanna district is by the Delaware and Hudson Canal, over which passes about 1,400,000 tons per annum. This system consists of 26½ miles of railway from the coal mines to Honesdale, and 108 miles of canal from this point to Rondout, their depôt on the Hudson river; from Rondout to New York is a further distance of 90 miles—in all 224½ miles.

A direct railroad would not exceed 130 miles, and would have the advantage of rendering the collieries independent of the navigation, always frozen in winter.

The mode of working is, by driving one or more "headings, or gangways," a little to the rise of water level, out of which are driven "chambers," from 36 to 50 feet in width; between the chambers a rib of coal is left, 14 feet thick, holed at every 18 feet; this rib is afterwards robbed, so that, I was informed, not more than 10 per cent. of coal is lost. The kirving is either made in the bottom, or above the bottom bench; a large quantity of powder is used. One mining agent informed me, that in working an 18 feet seam, he sometimes threw 200 tons of coal.

Each heading is capable of producing 250 tons and upwards per day, but occasionally four are in daily working for 500 tons.

The headings, or gangways, are sometimes laid with malleable iron rails, but as frequently with wooden ones plated; in the chambers stout wooden rails are used.

The coals are brought out by mules, going with four or five waggons, carrying from 30 to 40 cwts. each. These mules are large animals, and are said to cost about £30 each.

COST OF WORKING.

The cost of working naturally varies, according to the situation, nature, and depth of the seams. In mines where the coal is wrought by a day level, the cost may be averaged at 70 cents per ton upon the marketable coal; whereas, in mines wrought by means of shafts, and troubled with water, the cost may range from 73 to 77 cents per ton; the cost of lifting water varying from 5 to 8 cents per ton.

The above costs are, in both cases, exclusive of rent and interest upon capital, and are made up as follows:—

	Per ton.	Per ton.
Mining and filling into waggons	45 cents ...	44 cents
Manager, boss, and sundry work	7 „ ...	7 „
Haulage in mines, and upholding mules...	4 „ ...	5 „
Timber (your own)	3 when bought	5 „
Iron, and other materials	1 „ ...	1 „
Breaking and cleaning coal at bank ...	10 „ ...	10 „
Pumping water	0 „ ...	5 „
	70 „	77 „

The cost of mining and filling varies considerably in some cases, being dependent upon the season of the year. At a colliery at Archbald, the

	Per ton.
Summer price was	47 cents.
Winter	45 "
Present price, owing to the war	53 "

The cost of timber depends much upon whether your coal land, or royalty, possesses any, or you have to purchase. The royalties which I examined were, for the most part, covered by primeval forest, hence the cost in their case was trifling.

Where shafts have to be sunk, from their large size and the nature of the strata they have to pass through, they form serious items in the expenditure.

They are sunk in a rectangular shape, of the following dimensions, so as to admit of bringing to bank the large wagons in use, and of a back, or pumping shaft:—Length, 18, 21, and 23 feet; breadth, 10 and 12 feet. Their cost for sinking is £40 or £42 per fathom, and this only for a depth of 200 feet.

The pitmen (called miners) generally build and find their own cottages. They are built of wood, as, for the most part, are nearly all the houses in the districts I visited.

When the coal "operators" build them, they cost about £30 each, and are let to pay a large interest.

The winding engines are generally driven by boilers 2 ft. 6 in. in diameter, pressed as high as 75 lbs. and upwards per square inch.

Though not strictly belonging to my subject, I may be allowed to make some remarks upon the railroads carrying the produce of this coal-field.

As may be expected, they are by no means so well made as in this country. In some parts they are only laid with a single way; nevertheless, they contrive to lead large quantities of coals.

Between Archbald and Carbondale, the Delaware and Hudson Canal Company have two distinct lines, one of which is called a gravity line, and is used entirely for the full wagons.

The local railroads are paying dividends of from 7 to 10 per cent. The dues charged are two cents per ton per mile.

Some experiments have been made upon the New Jersey Central Railroad, to ascertain the respective cost of working locomotive engines with coal and with wood.

		Cost per Mile.
Engines burning wood	... ...	14⅓ cents.
„ „	wood and bituminous coal mixed ...	12⅕ „
„ „	anthracite	10½ „

Upon a comparison of two engines running with passenger trains, one using anthracite and the other wood, it was found that the cost of fuel was three cents per mile, or about 35 per cent. in favour of anthracite over wood. More experience is required to average the cost of maintenance of engines.

I may remark, that wood is as yet very accessible, the railroads in many places passing through pine forests; and you may occasionally see the wood being cut into suitable lengths by means of a small circular saw, driven by a horse working in a box, *i.e.*, walking up an endless incline, pretty much as turnspits were employed of old.

SCHUYLKILL DISTRICT.

The Schuylkill district, to which I paid a short visit, is much more broken up than the Wyoming valley, and the strata also are considerably contorted, throwing the seams to an average angle of 37°; hence the cost of mining is considerably higher than in the Lackawanna valley. The cost of mining varies from 1·25 dollar to 1·50 dollar per ton, including an average rent of 27 cents per ton, which is found to be too high; but if the working charges are higher, so are the selling prices, averaging 1·85 dollar per ton—the "coal operators," as they are called, being free to avail themselves of the open market.

There are about 100 collieries working, many of them upon a very small scale, vending 4000 or 5000 tons per annum. Some few are doing an extensive business, among which may be particularised that belonging to Messrs. R. Heckscher and Borda, who, out of five shafts or slopes, drew 274,844 tons last year.

There are few shafts in this district. As a rule, the collieries are worked upon a very shortsighted system, viz., by "a slope," driven to the dip of the coal, which is then wrought to the rise; this, when exhausted, necessitates the continuing of the slope, and repeating the process. It may easily be seen that, working upon this plan, the cost of production must yearly increase, especially when the water is allowed to follow down.

The cost of the collieries, according to Mr. Petherick, of Pottsville, a Mining Engineer of considerable standing, ranges from £6000 to £8000.

To this gentleman I am indebted for sections of this coal-field and much other valuable information.

Though some of the collieries are realizing large profits at present, Mr. Petherick stated that scarcely ten per cent. of the "operators" had made fortunes—in this respect they bear a no distant parallel to the coal-owners of this country.

Coal breakers or crushers, introduced in 1844, are here in full play, and the waste caused by them is variously estimated up to 33 per cent., which can be readily believed when the vast mountains of small coals are seen. Some advocates for these wretched machines defend them on the ground that the coal cannot be cleaned without them. This opinion is open to great doubt.

The following is the average result of 13 experiments, made with various descriptions of breakers, in the adjoining Lehigh district:—

	Per Cent.
Broken coal	22·36
Egg	14·66
Stove	21·99
Nut	14·82
Pea and waste	26·24
	100·07

The bulk of the produce of this coal-field passes over the Reading Railroad to Philadelphia.

The coal may be described as very similar in quality to that produced in the Wyoming valley; each has its advocates. Some of the seams here leave a red ash. It is said, that for stoves or closed furnaces, white ash coal is preferable, but for open-air grates, red ash coal.

According to Professor Rogers, the following is the analysis of the Pottsville coal:—

Carbon	94·1
Volatile Matter	1·4
Ashes	4·5
	100·0

Specific gravity, 1·472.

Some of the seams, generally called veins, are of great thickness. The Mammoth vein, working at the St. Clair Colliery, near Pottsville, is from 20 to 25 feet thick.—A section of the strata at this colliery is appended (see p. 38).

At Glendower Colliery, near New Boston, west of Hecksherville, is the following section of a seam, supposed to be the Mammoth:—

Top Rock.

	Feet.	In.
Slate roof	0	10
Coal	4	11
Slate	1	6
Coal	2	0
Slate	2	0
Coal	3	9
Slate	0	7
Coal	2	6
Slate	0	2
Coal	5	0
Slate	1	2
Coal	5	0
Slate	0	2
Coal	10	0
Slate and bone	1	0
Coal	2	0
Slate	1	0
Coal	7	0
	49	9

Coal	42	2		
Slate	7	7		
			49	9

Transverse section of seam from outcrop to outcrop, 300 yards.

The section of the strata cut through by the Randolph Tunnel, in the Sharp Mountain at Port Carbon, near Pottsville, is produced (see page 38). This tunnel is by no means through the coal measures; it will be observed that two beds of conglomerate are passed through, and that No. 10 vein is occasionally found 50 feet thick.

				Tons.
The aggregate produce of the anthracite coal-fields was, in			1861 ...	7,484,672
Ditto	ditto	ditto	1862 ...	7,481,719

The whole of which was sent to the sea-board, with the exception of 500,000 tons consumed inland.

This paper would scarcely be complete without saying something of the workmen employed in the mines. The bulk of them are from Ireland, with a sprinkling of Welsh and English. I regret to say, that however unreasonable and prone to strike our own pitmen are, the miners here are more so; in fact, I found the men in the Wyoming valley very generally on strike, because the weighing "Boss" (a name given, I believe, to all chargemen) at one of the collieries had displeased the men. At Messrs. Heckscher and Borda's extensive collieries in Schuylkill, at the time of my visit, the men were on strike because the owners had appointed a Welsh underground manager, Mr. Jones from Wilkesbarre, instead of one of themselves.

As Mr. Jones's miners had brought several of the habits of the old country with them, having shot at four men the previous week—one of whom was dead—he deemed it prudent not to disobey the notice which he had received from them, and which he showed me at our hotel in Pottsville, where he had taken refuge. A complete reign of terror existed in the neighbourhood of the collieries on strike.

The pitmen generally, when at work, were making from two to three dollars per day.

SECTION OF THE STRATA NEAR SCRANTON, IN THE WYOMING VALLEY, AT A POINT MARKED **A** ON THE PLAN.

	Ft.	In.
Black slate.		
Coarse grey massive micaceous sandstone.		
Coal	8	0
Fire clay.		
Coarse grey micaceous sandstone.		
Coal	3	0
Blue sandy shale, with balls of iron ore.		
Soft clay shale.		
Coal	5	0
Blue sandy micaceous slate.		
Shelly micaceous sandstone and shale.		
Coal	7	0
Slate.		
Blue clay shale (ferns and lepidodendra).		
Coal	10	0
Shales.		
Slaty micaceous sandstone.		
Coal	6	0
Shales.		
Sandy slate.		
Coal	14	0
Black slate and shale.		
Micaceous flaky sandstone.		
Coal	2	0
Ore shale.		
Sandstone.		
Coal	8	0
Shale.		

	Ft.	In.
Fire clay and shale.		
Blue slate.		
Coal	2	0
Stigmaria shale.		
Coal	6	0
Stigmaria shale.		
Sandstone.		
Massive micaceous sandstone.		
Coal	4	0
Stigmaria fire-clay.		
Coarse grey micaceous sandstone.		
Coal	1	0
Blue stigmaria shale.		
Coal	2	0
Stigmaria shale.		
Nut and pea conglomerate.		

SECTION OF STRATA AT A POINT MARKED B ON THE PLAN.

		Ft.	In.	Ft.	In.	Ft.	In.
Surface gravel						2	0
Micaceous sandstone						58	0
7-feet seam ...	Slaty shale and coal			0	5		
	Good coal	3	0				
	Parting occasionally ½-inch						
	Good coal	0	6				
	Band (varies)	0	4				
	Good coal	2	11				
				6	9		
						7	2
Stigmaria clay and micaceous sandstone						22	0
10-feet seam, the most extensively worked in the valley.	Top coal	2	7				
	Band	0	5				
	Blacksmith coal	1	5				
	Band	0	11				
	Bottom coal	4	3				
						9	7
Stigmaria shale						15	0
Nodular iron ore						2	0
Coal						1	6
Sandstone and shale						12	0
Coal (1)	Good coal, dirty	0	6				
	Good coal	5	6				
						6	0
Stigmaria shale and micaceous sandstone						41	0

		Ft. In.	Ft. In.	Ft. In.
Coal (2) ...	Good coal ...	1 6		
	Band, slaty ...	0 0½		
	Good coal ...	4 10½		
				6 5
Stigmaria shale ...				
Micaceous sandstone ...				54 0
Black slate ...				
Coal (3) ...	Inferior coal, no use ...		0 5½	
	Band, slate ...		0 4½	
	Good coal spoiled by slate ...		0 9	
	Good coal ...		4 6	
				6 1
Slate ...				21 0
Micaceous sandstone ...				9 0
Coal ...				1 6
Stigmaria shale ...				30 0
Dark buff coloured sandstone ...				
Conglomerate ...				0 0

The three seams marked 1, 2, 3, are extensively worked at Dunmore Colliery; that produced from No. 3 seam is considered the best for steam purposes, but all are pretty much of the same character.

SECTION OF THE STRATA NORTH OF ARCHBALD, AT POINT MARKED C ON THE MAP.

		Ft. In.	Ft. In.	Ft. In.
Surface ...			0 0	
Coal ...			8 0	
				8 0
Fine black slate ...			17 0	
Coal ...			1 6	
				18 6
Sandstone, micaceous ...			46 0	
Coal ...			3 6	
				49 6
Sandstone, micaceous ...			59 6	
Coal ...			1 6	
				61 0
Sandstone, micaceous ...			30 0	
10 feet seam ...	Slaty coal cast back ...	0 3		
	Good coal (top bench) ...	2 1½		
	Slaty band ...	0 3		
	Good coal ...	0 6		
	Slaty band ...	0 6		
	Blacksmith coal ...	1 3½		
	Slaty band ...	0 3		
	Good coal (bottom bench) ...	5 0		
			10 2	
				40 2
	Carried forward ...			177 2

	Ft.	In.	Ft.	In.
Brought forward			177	2
Fine sandstone	30	0		
Coal, working 5 feet at Carbondale	4	0		
			34	0
Coal sandstone			75	0
Conglomerate, supposed thickness			50	0
Total feet ...			336	2

SECTION OF THE STRATA SUNK THROUGH IN THE SHAFT OF THE ST. CLAIR MINE, NEAR POTTSVILLE, IN THE SCHUYLKILL COAL-FIELD.

	Ft.	Ft.
Slate and rock	119	
Primrose coal (burns to grey ash)	8	
		127
Slate and rock	68	
Holmer coal (burns to white ash)	4	
		72
Rock	78	
Small scares of coal	0	
Slate and rock	125	
Seven feet vein—7 to 19 feet—(burns to white ash) ...	7	
		210
Slate	14	
Mammoth vein (burns to white ash)	25	
		39
Slate and rock	75	
Skidmore vein (burns to white ash)	7	
		82
Total feet ...		530

Rock and slate	479	
Coal	51	
		530

UPPER VEINS, DENUDED AT THE ST. CLAIR WINNING.

		Ft.	In.
Descending,	Little Tracey	3	0
„	Big Tracey	7	0
„	Clinton	3	6
„	Peacock	7 to 8 feet	
„	Diamond		

HORIZONTAL SECTION OF THE HIGHLY-INCLINED STRATA CUT THROUGH AT THE RANDOLPH TUNNEL, SHARP MOUNTAIN, PORT CARBON.

	Ft	In.
Tunnel mouth.		
Sandstone.		
Coal, vein No. 1, said to be N. dip, Salem S.; 50 yards gangway driven E.; course N. 67, 30 E.	3	2
Hard black slate mixed with sand rock.		
Bed of sand rock.		

	Ft.	In.
Sandstone with slate.		
Coal, vein No. 2, soft dirty	2	2
Soft blue slate.		
Sandstone and slate.		
Sandstone.		
Hard close blue rock.		
Sandstone mixed with slate.		
Hard grey sandstone,		
Blue rock and slate.		
Soft blue slate and sandstone.		
Coal, vein No. 3, dirty	1	1
Blue slate	1	7
Blue leafy slate	2	1
Sandstone and slate.		
Hard blue rock.		
Conglomerate.		
Hard grey rock.		
Soft blue slate with seams of coal.		
Hard black jointy slate.		
Hard grey rock.		
Hard blue slate.		
Soft light-blue slate.		
Soft coaly slate.		
Coal, vein No. 4, good hard coal, said to be the N. dip of Rabbit-hole, 60 yards gangway W., and 10 yards to fault E.	2	3
Black shelly slate.		
Hard blue slate.		
Coal, vein No. 5, said to be the Tunnel vein, very much confused; 20 yards gangway E, 12 yards W. ...	14	0
Black slate.		
Blue slate.		
Close grey rock.		
Hard blue gritty slate.		
Close grey rock.		
Hard gritty slate.		
Hard close rock.		
Black slate.		
Grey rock.		
Mixed slate and rock.		
Coal, vein No. 6, pinched out in tunnel, but opens above	0	5
Slate.		
Mixed coal dirt and slate.		
Close grey sandstone.		
Slate.		
Coal, vein No. 7	2	5
Slate.		

	Ft.	In.
Coal dirt and slate.		
Rock.		
Black heavy slate.		
Coal, vein No. 8, Furnace vein, supposed to be N. dip of Black Mine	6	0
Black slate.		
Blue slate.		
Grey rock.		
Slate.		
Rock.		
Coal leader	1	0
Slate.		
Conglomerate.		
Hard black slate.		
Grey rock.		
Hard blue slate.		
Rock.		
Slate.		
Black coaly slate.		
Coal leader	1	1
Slate.		
Coal leader	1	0
Slate.		
Rock.		
Blue slate		
Black slate.		
Blue slate.		
Coal, vein No. 9, called by some dirty, by others smut vein ; 4 ft. to 5 ft. good coal bottom ; dirt on top ; vein sometimes 50 ft. thick	7	2
Black slate.		
Blue slate.		
Rock.		
Slate.		
Rock.		
Slate.		
Rock.		
Slate.		
Coal, vein No. 10	2	4
Slate.		
Coal, vein No. 11, the Barcleugh vein	8	3
Slate.		

Tunnel closed, said to have been driven 45 yards farther.

Coal, vein No 12, about 45 ft from Barcleugh vein.

Coal, vein No. 13, said to be the Black Lead vein, about 90 ft. from the Barcleugh.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, DECEMBER 3, 1863, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

The minutes of the Council having been read,

The following gentlemen were elected members:—Mr. Andrew Knowles, Eagley Bank, Bolton, Lancashire; Mr. Robert Reed, Wardley Colliery. Mr. Emmerson Bainbridge, Rainton Colliery, was elected a graduate.

The President said, that a paper had been presented to the Institute, respecting a Mining-fund in Belgium, which was a very interesting document. It had been laid before the Council, who had authorized it to be read. He would, therefore, propose that it should be printed in their Transactions. It was scarcely necessary to take up the time of the meeting by reading the paper, as it comprised several statistical tables, which would be best understood by reading them in print.

It having been unanimously resolved that the paper be printed and inserted in the Proceedings of the Institute,

The President said, the next paper on the list was Messrs. Wood and Boyd's paper on "The Ancient Drift through a portion of the Coal-field of Durham." This had already been read to the British Association. The Council had agreed that it should be printed, and such plates as were necessary to illustrate the paper would be engraved. If the meeting thought well, it could be printed, and the discussion on the paper would be taken afterwards.

A motion to that effect was carried by show of hands, and the same resolution was come to with regard to Mr. Dunn's paper "On the Cumberland Coal-field and the New-red-sandstone."

The PRESIDENT said, the next subject for discussion was Messrs. Wood, Taylor, and Marley's paper "On Coal, Coke, and Coal Mining." His two colleagues were not present, but he would read over the heads of the papers, and they could be discussed seriatim. It was divided into eleven heads [See Transactions, Vol. XII., page 149]. The first was, "*The Geological Description of the Northern Coal-field.*" It contained some important statistics, especially with respect to the Synopsis of the coal seams.

Mr. ATKINSON—Do you agree with Mr. Buddle's Synopsis?

The PRESIDENT said, it was based on Mr. Buddle's Synopsis; but a great deal of information had been obtained since that was published, and it had been altered accordingly.

Mr. ATKINSON wished to know what seam the Brancepeth seam was identified with.

The PRESIDENT said, the Brancepeth seam was taken to be the Brockwell seam.

Mr. ATKINSON said, he had been examining these seams, and they said, in the Brancepeth district, that they had the Harvey seam, and in the Auckland district the Brockwell seam.

Mr. BOYD said, it was desirable to know whether the Busty Bank comprehended the Five-quarter and Six-quarter seams at Wylam.

Mr. ATKINSON said, he considered the lower part of the Auckland Main coal, now called the Brockwell seam, was the Brancepeth seam. There was a band came in at Bitchburn, which divided the seam so as to form two seams further eastward. He thought the lower part of the seam was the Brancepeth seam. The President called it the Brockwell seam.

The PRESIDENT asked if there was any seam at Brancepeth corresponding to the Harvey seam.

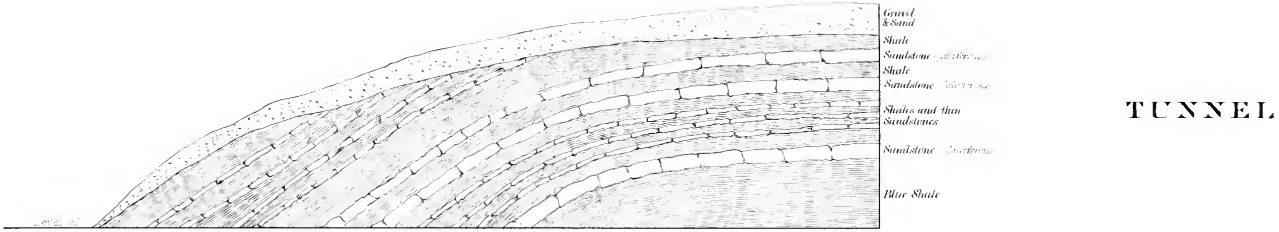
Mr. ATKINSON said, the seams there were so thin, that if there was any it had never been identified, to his satisfaction, as the Harvey seam.

The PRESIDENT said, the general section given in this paper, was a section of the strata through the Coal and Carboniferous series, from the county of Durham into Scotland. Since this was printed, he had

TUNNEL NORTH OF RICCARTON JUNCTION, BORDER COU

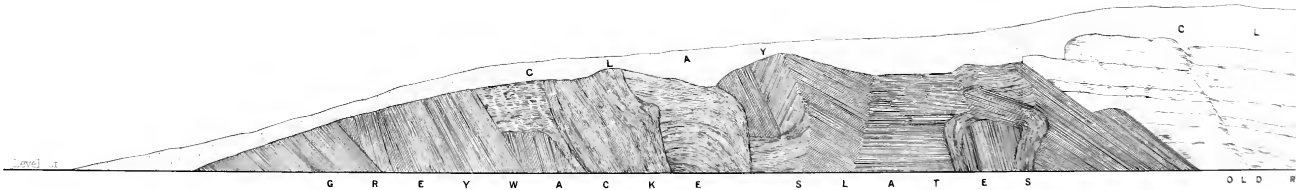
N°. 1.

SECTION OF CUTTING SOUTH END OF TUNNEL.



N°. 3.

SECTION OF CUTTING (PALMERS HILL) B



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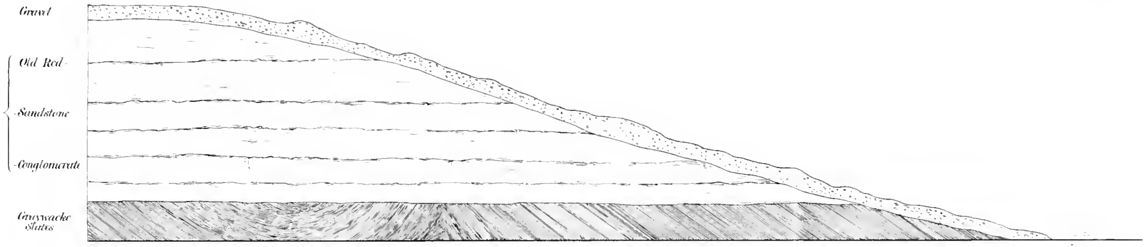
JNCTION, BORDER COUNTIES RAILWAY.

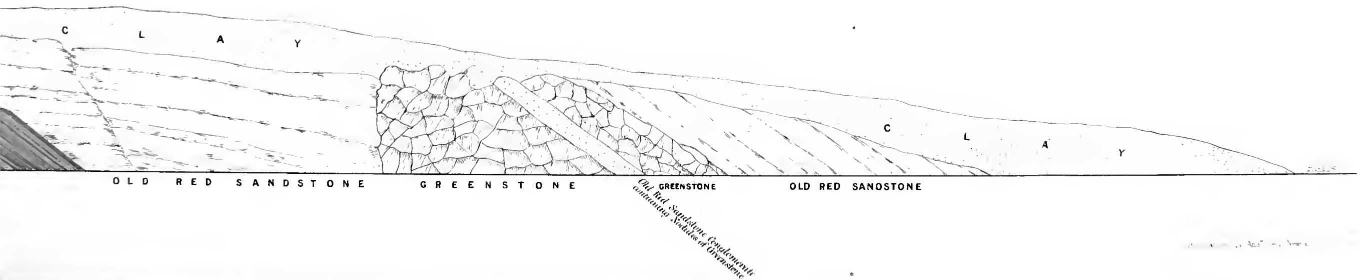
NNEL

SECTION OF CUTTING NORTH END OF TUNNEL.

No. 2.



NG (PALMERS HILL) BORDER COUNTIES RAILWAY.



been investigating more particularly the strata at the bottom of the Carboniferous series, and their connection with the Silurian rocks. He had made sections of portions of these, which were very interesting. It was a great point to ascertain clearly the connection of the lowest beds of the Carboniferous series with the Silurian rocks, as it comprised the termination of one series of deposits, viz., the Silurian, and the commencement of another series—the Carboniferous, which latter were deposited upon the then existing surface of the former series, and were unconformable to each other, forming the end of one and the beginning of another epoch in Geology. The section (Plate IV., No. 1) shows the stratification near the bottom of the Carboniferous-rocks, at the south end of the tunnel at Riccarton. There, the limestone and sandstone of the bottom part of the Carboniferous-rocks are strictly conformable to each other. The section (Plate IV., No. 2) shows the connection between the Red-sandstone and the slates of the Silurian series—the slates are nearly vertical, and the sandstone quite horizontal. That sandstone is of a conglomerate nature, and is the Old-red-sandstone at the base of the Carboniferous-rocks, and has evidently been deposited quite horizontally on the vertical ends of the Silurian shales. It is seen for a considerable distance so stratified. This shows very clearly the relationship of the two formations, so far as this district is concerned—the Carboniferous deposits having evidently taken place quietly and undisturbed, and that they had continued so from the period of deposition to the present time at this particular spot, and showing incontestibly the end of one of the deposition of rocks and the beginning of another. There is another section (Plate IV., No. 3) which shows a similar deposit, where the Silurian rocks are much contorted; but it will be seen that the Old-red-sandstone is deposited almost horizontally, both on the edges and sides of the slates, and unconformable to them. They have not been deposited in connection with the slates, but on their sides and edges, as existing at the time.

Mr. Boyd—There is an intermixture of green-stone with the Old-red-sandstone.

The President—The green-stone is a protrusion very different from both.

Mr. Boyd—You call it igneous ?

The President—I suppose so; but it is a rock that constitutes a great many of the hills in that district—for instance, the Cheviots.

Mr. Boyd—Is it Amygdaloid trap ?

The President assented. It has apparently passed through the

Red-sandstone after the latter had been deposited. The first process, we may suppose, was the formation and disturbance of the Silurian slates. Then comes the deposit of the Old-red-sandstone quietly upon them; and afterwards, at a subsequent period, there had evidently been a protrusion of the porphyritic rocks through the Old-red-sandstone. Of course, such protrusion must have been subsequent to the formation and disturbance of the slates; and, likewise as seen by the section, subsequent to the deposit of the Old-red-sandstone. We do not pretend to say at what period. The green-stone, it will be seen, elevates the Old-red-sandstone on the south side, and even a portion of it is included within the mass of green-stone. These sandstones, of the Carboniferous-rocks, comprise a very great number of beds. The protrusion of the green-stone has, no doubt, been subsequent to the deposit of all these beds in that district; because, the protrusion of the green-stone through the Carboniferous beds always moves and distorts them. In the Cheviot Hills district, the strata underneath, and connected with the deposit of the coal in the North of Northumberland, has been described by Mr. Boyd. I have also made another small section (Plate V., No. 4), which shows more clearly than the general section (Vol. XII., page 151, No. 5) the strata in the neighbourhood of Canonbie. This section is also useful in illustrating the general position of these rocks. The Canonbie section shows a portion of the New-red-sandstone at the very top of the Coal-measures. That previously spoken of, viz., the Old-red-sandstone, is at the very bottom of the Carboniferous series.

Mr. Daglish—Is that the New-red-sandstone at the top?

The President—I think it is.

Mr. Daglish—What proof have we that it is so?

The President—We have no positive proof; but I think we may infer that it is.

Mr. Daglish—These red beds are lying perfectly conformable to the Coal-measures at Canonbie.

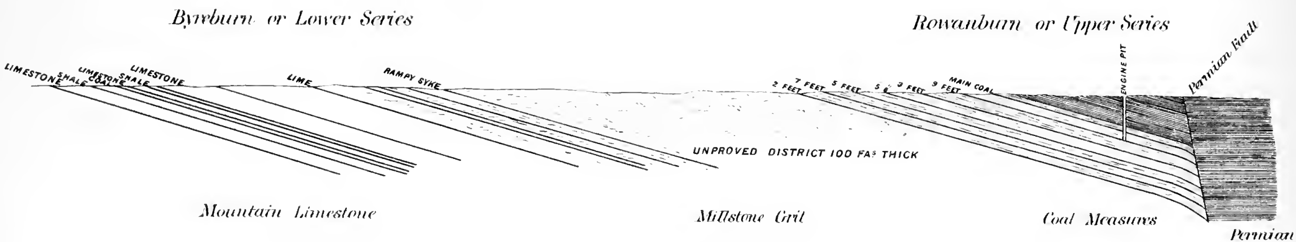
The President—You have New-red-sandstone at the top of the Coal-measures.

Mr. Daglish—You have so-called New-red-sandstone at the top of the Coal-measures at Monkwearmouth, and the same at Wingate, where a hundred fathoms of the Coal-measures are off.

The President—There is a distinction between the New-red-sandstone lying above the Magnesian-limestone, and the Red-sandstone at the top of the Coal-measures, lying unconformable to it. This is

No. 4.

Section of Canonbie Coal Field.



generally, in the Durham district, separated by sand, the sand being at the bottom of the Magnesian-limestone, and at the top of the Lower-red-sandstone. In the sinkings and borings through the Magnesian-limestone to the Coal-measures, you pass through the Red-sandstone into the Coal-measures. It is not known whether this Red-sandstone is a parallel formation with the Red-sandstone at Canonbie. It may be that the Red-sandstone is thicker at Canonbie, and be conformable with the Coal-measures. It is divided by a fault as shown in the section No. 4, and the fault may bring the two Red-sandstones into the same line of section.

Mr. Dunn said, the Red-sandstone visible at Canonbie was traceable all the way from Longtown. This was proved to be the very same as at Maryport.

Mr. Boyd—Is that not an answer to your question?

Mr. Daglish—No; the Red-sandstone alluded to by Mr. Dunn, is on the other side of the Great Dyke. The rocks, both at Canonbie and in Durham, though red, may be merely discoloured measures.

The President—I have always stated that the precise position of this coal-field in the series was a debatable point. I do not think this section decides the question. Probably we may arrive at some conclusion in the discussion.

Mr. Palmer—There is no doubt about the Red-sandstone lying on the Coal-measures. At Bristol we see it.

Mr. Daglish—Is it conformable or unconformable?

Mr. Palmer—Conformable.

The President—I do not know whether any of you could give us any information as to the Cockfield Basaltic Dyke running into the strata in the eastern part of the district of Durham. That dyke is stated to pass through the New-red-sandstone lying above the beds of the Permian series.

Mr. Atkinson—Is it the Whin Dyke or the Forty-fathom Fault?

The President—The Whin Dyke.

Mr. Atkinson—It has not been found to pass through and penetrate the Magnesian-limestone. It passes through the Coal-measures, but has not been found penetrating the Magnesian-limestone.

Mr. Daglish—It is said to pass through the Oolite; and if so, it must pass through the Magnesian-limestone.

Mr. Boyd—In my recent visit to Rosedale, in Cleveland, a basaltic dyke was described to me to the east of Rosedale, passing through the Oolite and the upper formation of the Cleveland Hills. A basaltic dyke is also quarried in the New-red-sandstone series at Preston, and other places on the Tees, and this is understood to be the Cockfield Dyke. This may be in the same course as the Dyke you are speaking of.

The PRESIDENT, reverting to the discussion on the paper, said, the second division is "*On the Economic Uses of the various Beds of Coal in the North of England Coal-field;*" and the third is "*The Early History of Coal and Coke, and particularly in the Northern Districts.*"

Mr. GREEN—How do you account for the best fire-clay always occurring under the lower beds of coal in the series—the coal and coke seams?

Mr. DAGLISH—That is begging the question as to the quality.

Mr. SOUTHERN disputed whether it was the best.

Mr. GREEN said, the best fire-clay in the Crook district is so situated.

The PRESIDENT—If you judge of the quality by the quantity worked, the greater part is worked in the Auckland district.

Mr. ATKINSON—There is a great need of fire-clay where coke is made, and it is therefore worked to a greater extent in such places.

Mr. DAGLISH—There is a great quantity of excellent fire-clay in the thill of the Main coal, which is not a lower seam near Washington.

Mr. BERKLEY drew attention to the following statement in page 162:—"The lowest seams at Etherley, &c., are the seams parallel to the Garesfield or Brockwell seam." He said the Garesfield was not the Brockwell seam. In the next paragraph reference was made to "The Harvey, or Beaumont seam." He asked if it did not correspond to our Busty Bank?

The PRESIDENT—I think not.

Mr. BERKLEY thought it did. He understood, that in the Marley Hill district these seams all go together to form the Busty Bank.

The PRESIDENT—The tabular statement was taken from Mr. Buddle's account. The Harvey seam was sunk to at the Black Boy, and they certainly had the Brockwell a considerable distance below it; and they had also what they called the Busty Bank, comprising, what at Marley Hill, forms the Six-quarter coal.

Mr. BERKLEY said, he considered the Harvey seam was also connected with other similar seams to form the Busty Bank.

Mr. BOYD said, Lintz Colliery works the Busty Bank. It was very desirable to trace the identity of the seam from Medomsley to the Tyne at Ryton and Wylam, and he thought Lintz was the link between the two. The 40-fathom dyke, which passes near Hamsterly Hall, was supposed to cause the difference observable in the classification. He thought it was not the cause, because Lintz was admitted to be on the north side of that dyke, and it was also admitted to be the Busty Bank seam. On the south side, were Medomsley and Consett having nearly the same section of the Busty Bank. Therefore they were identified on both sides of the dyke, but they could not be traced through Ryton.

Mr. BERKLEY said, they were denuded. You have to find them on the opposite hill, where they come to the day.

Mr. BOYD—The Derwent Valley denudes all, even the lowest one.

The PRESIDENT thought the Garesfield beds were below the Derwent.

Mr. BOYD said, he knew it was denuded at Ebchester; but at Hedley, on the opposite side of the Derwent, all four seams were found—the Brockwell, the Yard-seam, the Five-quarter, and the Upper Five-quarter, or Stone-coal.

The PRESIDENT said, he now came to the fifth division, viz., "*An Account of New Discoveries, and their application connected with the Coal and Coke Trade.*" Here they alluded to the boring at Middlesbro', which would be explained in Mr. Marley's paper. The President next referred to an awkward mistake in a publication by Mr. Handel Cossham, on "Corn, Coal, and Cotton, the Three Kings that rule the world." It was stated that the Royal Society of Edinburgh, had come to a resolution, in discussing the question of the Boghead mineral, "That in the present state of science it was impossible to determine what coal is." Professor Rankin, of Glasgow, referred to the minutes of the Society and found that no such resolution had been passed. The next division was "*On the Sinking of Pits and the Drainage of Mines.*"

Mr. DUNN said, a great deal might be made of the different engine powers. The Cornish engines were said to be superior to those employed in the North.

The PRESIDENT—I believe Sir William Armstrong gave some account of the power of engines to the Association.

Mr. DUNN—In Cornwall they regularly publish statistics of the quantity of water raised. The question was whether their engines *were* superior.

The PRESIDENT—The pumping engine at Harton is the only one in this district on the Cornish principle. The eighth division was "*On the Ventilation of Mines;*" the ninth "*On the Underground Conveyance of Coal;*" and the tenth "*On the Effects Produced by the Introduction of Railways, Locomotives, Screw Steamers, and Inland Competition.*" On this subject, the President referred to the performances of the screw steamer Killingworth. The last subject touched upon, was the "*Duration of the Coal-field.*" Sir William Armstrong was of opinion that it would last 200 years; but he (the President) thought this was far too low an estimate. However, the Association had awarded £100 to a committee to investigate the subject. As regards that portion of the coal-field which was under the sea, not one square mile of that vast space had been explored; but any investigation of that subject could be of no practical utility at present.

PARADOXES IN VENTILATION.

The President said, at the previous discussion of the subject, Mr. Berkley, Mr. Heckels, and Mr. Boyd, had promised to give some information on the subject. He had a letter from Mr. Heckels, stating he could not be here to-day, but he would be prepared at the next meeting to go into the subject.

Mr. Berkley said, as far as he recollected it was the case of the Springwell air-ways. It was merely a description that he (Mr. Berkley) would give of some of the air-ways.

Mr. Atkinson said, as regards the possibility of having two separate upcasts, with a ventilation common to both, Mr. Heckels thought it very unsafe and almost impracticable.

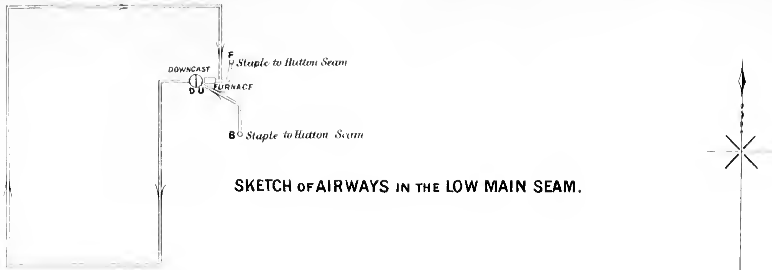
Mr. Berkley said, all he had to do was to give the following description:—

Explanation of Air-ways at Springwell, in their Present Position.

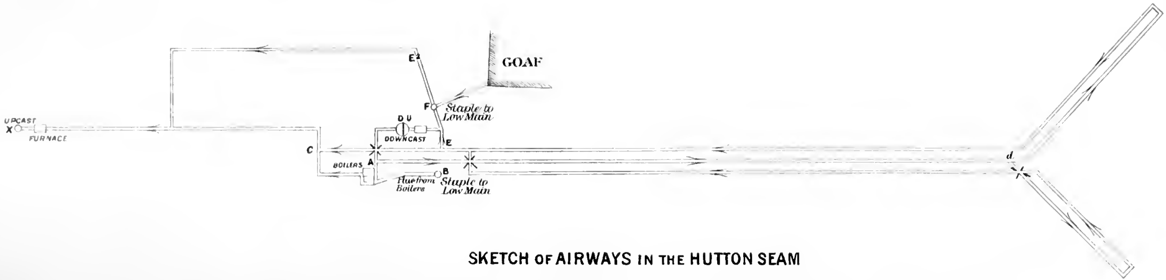
The downcast shaft is 14 feet diameter, divided by a brattice; the smaller side, the versed-sine of which is 4½ feet, is an upcast. We will call the downcast side D and the upcast U.

The air descends the side of the brattice D, a small split of 2000 or 3000 feet going into the Low Main seam (9½ fathoms from the bottom) to air some old workings, the remainder going to the Hutton seam divides at the bottom of the shaft. One portion, about 30,000 feet per minute, passing by means of an incline drift and staple, up to the Maudlin seam (21 fathoms above Hutton seam), ventilates these workings and returns to the upcast U. These air-ways are not shown on the sketch as they have nothing to do with the point under discussion. The other portion passes along the blue line to top of engine bank A, where a split of air goes to the boilers; one part of this split passes through the fires

DIAGRAM REFERRED TO IN Mr. BERKLEY'S ACCOUNT OF THE SPRINGWELL AIR-WAYS.



SKETCH OF AIRWAYS IN THE LOW MAIN SEAM.



SKETCH OF AIRWAYS IN THE HUTTON SEAM

Lithographed by A. Reid Newcastle

and returns east to a staple B, up to the Low Main seam, and so to the upcast pit U. The other part of this split passes over the top of the boilers, and joins the main returns at a point C. The main body of the air, about 27,000 feet per minute, passes down from top of engine bank A, dividing into two main currents at the point d; and after ventilating the workings, returns as shown by the red lines, to a point E, where the return divides, a portion going direct west to the upcast X, and a portion going north, is joined by the small split of air from the Low Main seam at F, passes on to E^2 round some north workings, and so west to upcast X.

The small split passing into the Low Main seam ventilates a block of workings, and returns to a staple F, down which it goes into the Hutton seam and joins the Hutton seam return at the foot of staple F.

Neither the furnace in the Hutton seam, or Low Main seam, adjoining the upcast U are at work. Stoppings at both furnaces cut off any connection with the upcast U. The pressure of the air against these stoppings is from the upcast U towards the Hutton seam returns.

The Air-ways as they were Formerly.

The whole of the colliery was formerly ventilated by means of the furnace at the foot of the bratticed upcast U, but when the upcast X was brought into operation this furnace was discontinued, and a stopping put in at the furnace.

The furnace in the Low Main seam, adjoining the upcast U, was worked for some time, and the Hutton seam return split at the point E, part passing up the staple F, and over the Low Main furnace, up the upcast U.

The furnace, I am told, was never known to reverse, except when the tubbing burst in the upcast U, when the heavy fall of water overcame the power of the furnace.

Other ways in the Hutton seam communicated with the staple F, and inflammable gas came off in such quantities from the goaves, and being very imperfectly diluted by the return air, that it was considered unsafe to work the Low Main furnace, and it was consequently discontinued.

I have not given the whole of the air-ways; the intakes being, for the most part, double, and the returns treble and quadruple.

I must also state that there were some workings on the west side of the downcast D, and a split of air was taken to ventilate them; but at this time there were no workings in the Maudlin seam.

The gradient from west to east is a dip of 1 in 12 or 14.

Mr. Southern said, he was there at the time the furnace was laid off, and must say that that furnace did not reverse the current. It was not known to reverse it; and most certainly there was no reason of that sort for laying the furnace off at the Low Main seam. It was from causes stated by Mr. Berkley. It was in consequence of the fear of gas coming too near the furnace. This furnace would have been laid off sooner if it had not been required to assist the engine smoke to make the shaft upcast in consequence of so much water coming from the tubbing. Shortly before Mr. Heckels visited the colliery the tubbing burst, in repairing which, they took the opportunity of getting the plugs tightened. Afterwards the leakage of water was so much reduced that the engine smoke could make it cast up without the furnace, and they took occasion to lay that furnace off at once. This was the only reason.

Mr. Berkley read the following memorandum from the overman's book:—"June 27th, 1853. As much air when the Low Main furnace was out as when both furnaces were in." Mr. Dunn was down, not quite two months after the furnaces were out.

Mr. Southern said, he did not remember any difference of circumstances with regard to the boiler.

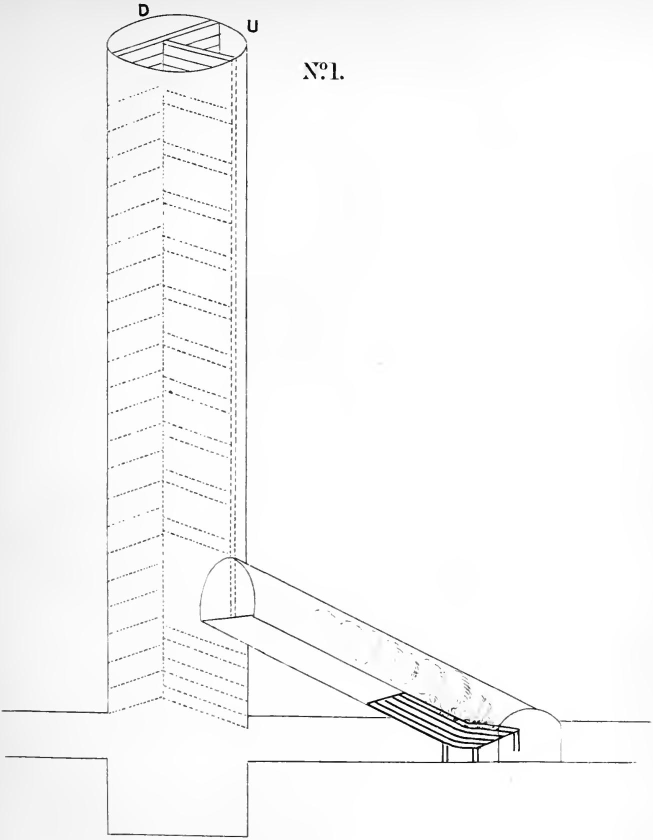
Mr. Dunn said, he was induced to bring Mr. Heckels to see, in operation, what he wanted him to adopt in Houghton Colliery. Mr. Heckels had a doubt whether it would answer, and he (Mr. Dunn) did not know whether he was convinced.

Mr. Southern—He was not convinced.

Mr. Boyd said, he had to bring forward two cases, to which he deemed it worthy to draw attention, as additional instances of those paradoxes in ventilation which have been, in so interesting a manner, produced by Messrs. Atkinson and Daglish.

The depth of the shaft, in the first case (see Plate VI., No. 1), was 180 fathoms; the shaft 11 feet diameter, divided into nearly two equal parts, in the first case by a brattice of the usual 3-inch plank, and the upcast side V, again divided by a quarter brattice, close throughout, for facilities at that period in drawing coals. The heated return-air, after passing over the furnace at the bottom of the upcast side, reached the shaft about 4 fathoms above the seam. It was found, notwithstanding that the current of air was a very powerful one, and the furnace nine feet by seven—that the return-air, although having equal access to either and both sides of the upcast portion

DIAGRAMS RELATING TO Mr. BOYD'S PAPER ON PARADOXES IN VENTILATION.



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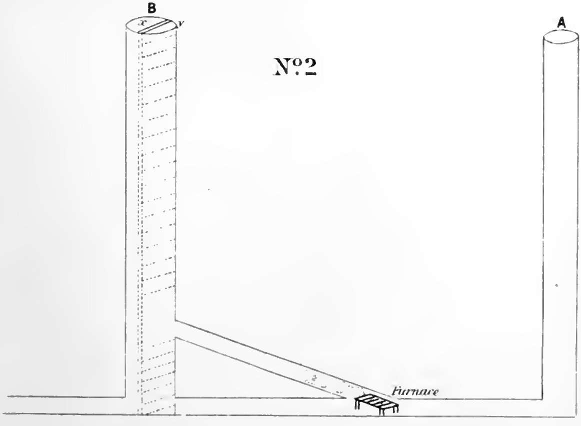


No. 2.

of the pit, divided as above by the quarter brattice—invariably confined itself in its ascent to one of the so divided quarter partitions. It was expected to increase the general ventilation if both these quarter divisions could be made to be occupied by the return current, and each alternate plank in the quarter brattice was removed with this intention; but this did not produce the effect, a downcast current still continuing to descend one of the quarter divisions. It was inconvenient to remove the whole of these quarter division planks, and the effect desired was not produced until a considerable extent of this quarter division planking nearest to the surface was removed, as well as those nearest the furnace drift mouth; after which both the quarter partitions of the shaft became upcasts, to the advantage of the extent of ventilation thereby acquired.

Mr. Southern—You will find something confirmatory of this in the Seaham pit.

Mr. Atkinson—I think there must have been some peculiarity in one of the shafts—I mean in one of the quarter divisions.

Mr. Boyd—The downcast was very much crowded with pumps. Both these quarter divisions were perfectly clear.

Mr. Tone said, this question must be decided by facts more than by reasoning. He found, with respect to valves for the discharge of water, that by partially shutting the valve you did not materially reduce the discharging power, unless the head was very small. By raising the valve partly, you could get as much discharged as if the whole valve were open. By applying to the passage through an orifice a small portion of a head of water—of say 200 feet head—applying a foot, or even two inches, you get a great increase of speed through a narrow orifice. You require particular observations before coming to any conclusion.

Mr. Boyd—This case was at Eppleton pit.

Mr. Southern—Was the quarter brattice divided in the upcast shaft equally?

Mr. Boyd—Yes, equally. We wished them to be both upcasts.

Mr. Atkinson—Did the furnace drift go in a fair line with the quarter brattice?

Mr. Boyd—Yes; there was an equal space open on each side of the area of the furnace drift.

Mr. Atkinson—What was the date of the observation?

Mr. Boyd—1836.

Mr. Boyd observed, that the second case (see Plate VI., No. 2) was of less importance. This was a shaft only 30 fathoms deep, divided by a brattice into two nearly equal parts—the diameter being, in this case, only nine feet. The ventilation was contracted; and, by sinking another shaft at a distance, to act as a downcast, the whole of the shaft was proposed to be used as the upcast, although the area of furnace was only six feet wide by six feet six inches in length, discharging its rarefied air into the shaft at about three fathoms above the seam, and confined, in the first instance, to only one side of the bratticed pit. A large portion of the brattice—say eight or nine feet in height—was removed in shaft B as soon as communication was formed with shaft A, with the intention of allowing the whole of the area of that shaft for purposes of the return current. In this case, the cold current continued to descend down the one-half (y) of the shaft B, the return current confining itself to the half side x, until the whole of the upper part of the division brattice was removed.

Mr. Tone—Would not the presence of damp in one of the divisions have some effect? If you had evaporation going on in one of them, that small circumstance might make a great difference. Of course the temperature would be different in that case. Were the circumstances the same as far as you can tell?

Mr. Boyd—As far as we could ascertain they were.

The President—Did you close the top of the upcast?

Mr. Boyd—No.

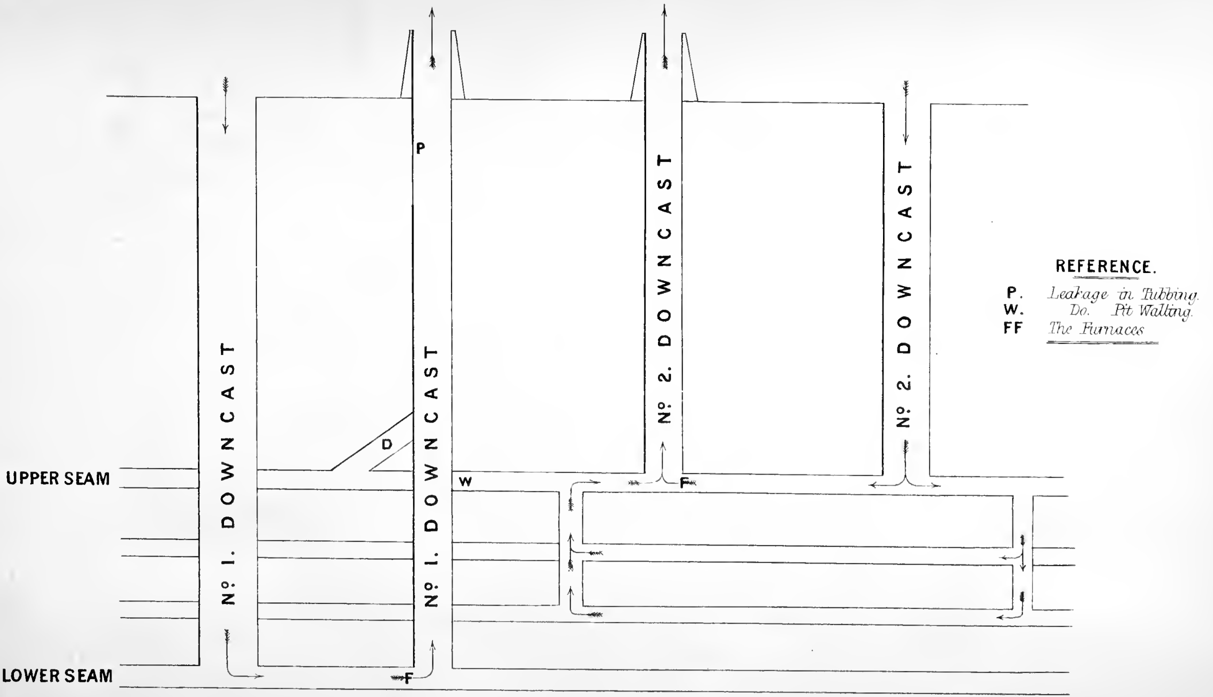
Mr. Berkley—Is it your opinion, in the other case, that if you had stopped the upcast, it would have turned the downcast into an upcast?

Mr. Boyd—I think both would have upcast then.

Mr. Berkley—Were the two sides exactly of the same area?

Mr. Boyd—Yes.

DIAGRAM REFERED TO IN Mr. HECKELS PAPER ON UPCAST SHAFTS, ETC. –



A Reid Lith Newcastle

ON UPCAST SHAFTS

AND

THEIR HEATED AIR-CURRENTS.

By Mr. R. HECKELS.

Having recently, at the Rooms of the Institute, attended a discussion on papers by Messrs. Atkinson and Daglish, at which I happened to remark, in allusion to air-currents in shafts, that I had known an instance of a portion of a highly-heated current finding its way from one upcast to another, and igniting in its passage a seam of coal standing in pillars, which, but for timely discovery, would probably have become a matter of serious consequence; and Mr. Wood, the President of the Institute, having, on my mentioning this, asked me to furnish a diagram to show under what circumstances the change in the direction of the upcast current occurred, and how the fire originated, I now beg to supply a diagram (see plate VII.), and to state the circumstances, which are the following :—

The colliery, at which there were at the time of these two occurrences two seams in course of working, was ventilated by means of two downcast and two upcast shafts. The downcasts are shown on the diagram as No. 1 and No. 2 downcasts, and the upcasts are also shown, and are respectively called No. 1 and No. 2 upcasts.

No. 1 downcast and No. 1 upcast—unconnected with the other shafts of the colliery—were used for the ventilation of the lower seam workings, at a depth from the surface of about 124 fathoms; and No. 2 downcast and No. 2 upcast, in like manner unconnected with any other shaft, were used for the ventilation of certain old wastes, in seams lying between the then working seams, as well as for the ventilation of the workings in the upper seam—the latter lying at a depth which, for the purpose of this statement, may be assumed to be of 70 fathoms below the surface.

The diameters of the shafts were—No. 1 downcast, 14 feet; No. 1 upcast, 7 feet 3 inches; No. 2 downcast, 12 feet; and No. 2 upcast, 8 feet.

Owing to No. 1 upcast being of small area, and to the air-courses in connection with it being from three to five or six miles in length, whilst the area of the No. 2 upcast was comparatively large, with its air-courses short, it was deemed desirable to keep up a much higher temperature in No. 1 upcast, for the ventilation of the lower seam workings, than was required in No. 2 upcast for the workings depending upon it; and the effect of the continued great heat in No. 1 small but deep upcast, was the damaging of the sheeting of the tubbing in the upper part of the shaft about the point marked P, and a consequent letting in of water, which naturally tended to diminish the temperature, and render, as an upcast, this pit less effective. The quantity of water finding its way through the tubbing was not, however, such as to materially injure or impede the air-currents, nor, indeed, was it such as to render its effects discernable in any of them; but the fact that water was proceeding from the tubbing—being evident from the emission of steam from the mouth of the upcast—it was deemed necessary to have the shaft examined; and, with a view to this, the furnace, which was 12 feet square and situated at the bottom of this shaft, was partially slackened. Subsequent to the slackening of the furnace, and before the time arranged for the inspection of the shaft, smoke was discovered in the waste of the upper seam, on its route to the No. 2 upcast; and, on search being made as to its origin, the coal of this seam, behind the walling marked W, and in the vicinity of No. 1 upcast pit, was found to be on fire; doubtless ignited by a portion of the heated current of the lower part of No. 1 upcast shaft passing through some opened joints in the shaft walling, and coming in contact with it.

I need hardly observe, that with openings in the joints of the No. 1 upcast shaft walling, however small, and communicating with the return air-courses in the upper seam leading to No. 2 upcast, that a current composed of a portion of the general ascending current in No. 1 upcast, would be formed immediately on the temperature of the upper part of No. 1 upcast shaft becoming reduced to below that of the No. 2 upcast shaft, whether by water proceeding from the tubbing, and by a partial slackening of the furnace below, or by any other cause; and I think it will be evident to all conversant with matters of the kind, that the coal, when in contact with the pit walling and exposed to the action of the heated current, could not fail to become ignited.

Having now described circumstances, not uncommon, under which so destructive an element as fire may at any moment have to be encountered, I am unwilling to leave this subject without explaining the means by which, in this case, it was extinguished; and as I do so for the benefit of those who may yet be inexperienced in such matters, I trust I shall not be considered tedious; for, although there is nothing to describe which may be new to many of the members of the Institute, there may, amongst the less experienced, be some who are practically unacquainted with a ready mode of getting water speedily brought through a highly-heated and smoky atmosphere, such as is to be met with in upcast shafts, or to a situation such as that in which the fire here alluded to existed, whether through a smoky and disagreeable medium or not.

On reference to the diagram will be seen a slope drift, marked D, which had, many years ago, been used as a furnace drift, through which alone, on the arrival of the workmen to extinguish the fire, No. 1 upcast shaft could, from the upper seam, be reached, in consequence of the fire having so rapidly spread amongst the holings round the shaft. Fruitless attempts were made to master the fire by means of water, brought a considerable distance in tubs, and by the application of fire-engines; and whilst, to some extent, although limited, these appliances, with others less effective, prevented the fire spreading so rapidly as it would otherwise have done, preparations were being made on the surface to effect, between it and the burning coal, a communication by means of pipes, which, when completed, speedily proved satisfactory, by affording a continuous supply of water under a vertical pressure of 70 fathoms, against which, when brought in contact with the fire, the latter disappeared more quickly than the most sanguine could have anticipated. The pipes were of wrought iron, and, if I recollect rightly, were of an inch and a half in diameter, furnished with screws, and were such as are generally used for the conveyance of gas. In making the communication, the pipes were one by one placed and screwed together between two round wire ropes, each pipe being clamped to the ropes before being lowered below the surface; and at the old furnace drift, marked D on the diagram, a hole was made through the shaft walling, where a man was placed, who caught the lower pipe on its arrival at that point, and it was there attached to hose pipes, carried down the drift, and forward to that section of the fire which appeared to be the most threatening and destructive; and there being a cistern placed at the top of the pit, well supplied with water, and connected with the pipes, evidence of the fire being got under soon became apparent, although in one situation, where a stopping was broached to get the jet applied, the heat was so excessive that an explosion, of considerable force, was experienced immediately on the water coming in contact with it. In a few hours after the application of the water from the pipes, the whole of the fire was completely extinguished; and from the strong nature of the roof of the seam, and of the coal itself, the damage done was happily found to be of no great extent.

So unexpected and untoward an event as this, I may remark, naturally led to the consideration of the best course to be taken to prevent its recurrence; and a wall was subsequently built at each seam, with a space left between it and the inner or original walling of the shaft; but, more recently, this No. 1 upcast has become substituted by one of much larger area, which is lined with fire-bricks as a best non-conductor of heat, so that the whole, or as nearly the whole as possible, of the heat obtainable from the fuel consumed at the furnace, might be effective as a ventilating power, and has, in conjunction with certain modifications in other arrangements, nearly quadrupled the amount of ventilation sometime previously existing.

ON THE CAISSES DE PREVOYANCE,

OR

NATIONAL MINERS' RELIEF FUNDS,

OF BELGIUM.

By DAVID P. MORISON.

At a time when "Miners' Provident and Relief Funds," and other similar associations for the purpose of securing aid to the sick or disabled miner, or to his survivors in case of death, are occupying so much of the attention of both the miners and the coal trade, a short summary, or digest, of the system brought to so large an amount of perfection in Belgium, and known there under the designation of "*Caisses de Prévoyance,*" may not be devoid of interest to the members of the Mining Institute.

This system has been eminently successful in gaining the confidence of both masters and men, by allowing both capital and labour to participate equally in the management and support of the association; and there are few mines indeed, in Belgium, that have not already enrolled themselves under the system.

I have selected as the basis of this notice, the *Caisse de Prévoyance* of the province of Hainaut and district of Mons, it being one of the most extensive and complete in its operations; and I have obtained the following condensed view of the constitution of the Association from the statutes and rules published by order of the Belgian Government, and the statistics and tables from the Annual Report of the General Committee of the *Caisse,* or Fund, for 1860.

The Association is composed of a general *(commune) Caisse de Prévoyance,* and of branch, or local funds—one being attached to every mine associated. Both of these classes have been authorized by Government for 10 years, dating from 1860.

The functions of the general fund will be understood from the following analysis of the rules, to which I shall at once advert without further preface.

Funds.—The assets and revenue of the general fund include the following principal items:—

1st. Balance in Treasurer's hand at commencement of year.

2nd. Per centage on the wages of every workman attached to the associated establishments.

3rd. Sum payable by the owners of all the collieries or mines enrolled under the Association.

4th. Donations and grants from the State and province.

5th. Private donations and legacies.

The per centage on the workmen's wages is three-quarters per cent., deducted from the sum paid to each miner as wages; and the sum payable by the owners is equal to this—or another three-quarters per cent., making a total of 1½ per cent. on the amount paid as wages by each colliery.

Of the revenue of the Association, 10 per cent. is retained in hand as a reserve fund; to this is added annually one-half of the surplus of the receipts over the payments. A portion of the remaining funds is also set aside each year for the education of the children, and the moral improvement of the miner himself.

The branch, or local funds, are supported by a small per centage deducted from the workmen's wages.

Management.—The affairs of the general fund are managed by a committee of twelve, six of whom are chosen by vote, at a general meeting of the representatives of the associated collieries, from among the owners or managers, and four from among the foremen, or the better class of workmen; the remaining two are, the head engineer of the district and the governor of the province, the latter being chairman. The first ten are elected for two years' duty, and are eligible for reëlection at the end of that period. Out of these a vice-chairman and secretary are chosen, and the committee then appoint their treasurer and visiting surgeon.

The duties of the committee (seven being a quorum) are—

1. To hold monthly meetings, at which the sums received and paid into the fund, are taken into consideration, as well as the reports from the branch *caisse.*

2. To publish annually a complete report of the affairs of the Association; in which shall be included abstracts of the transactions of the branch funds, and a statement of the assets of the Association; which report shall be read and passed at the annual general meeting.

3. To fix the amount to be devoted to the improvement and education of the associated miner and his children, and to see that it is properly and conformably employed.

The relief administered by the fund is classed under two heads—*ordinary* and *extraordinary*. Under the first head are included all temporary and life annuities granted by the committee; and under the latter, relief granted to miners infirm from age, and incapable of work. Those suffering from *hernia*, or rupture, are included under the first head. The amounts of the annuities are regulated by the funds in hand, and the decision of the committee is final and without appeal.

Life annuities are granted to the father, mother, grandfather or grandmother of any workman killed accidentally at an associated mine, when their only means of support at the time of the accident; to workmen disabled from any accident received as above; and to miners of above 70 years of age, incapable of work, and resident for at least 10 years at an associated mine.

Temporary annuities are granted to the children, under 12 years of age, of any associated miner accidentally killed; to the children, under 12, of miners in receipt of annuities as above; and to the infant brothers or sisters of miners accidentally killed, and dependent on them for support.

The annuity granted to a disabled miner is transferable to his widow on his decease, if married previous to the accident. Any widow re-marrying loses claim to this relief, but receives, as marriage portion, a sum equivalent to two years' relief.

Every child in receipt of relief must attend regularly, as soon as age allows, one of the district, or communal schools. A very wise and proper provision for securing the necessary rudiments of education to many who, otherwise, might be deprived of its advantages.

No annuity, or relief, is granted when the accident is the result of the miner's own neglect or imprudence, or in case of suicide; and in no case can the funds of the Association be employed in relieving the workmen of non-associated mines. No request for relief is acceded to by the general committee after six weeks have elapsed from the date of the accident. The branch fund of the mine at which the accident occurred, supplies all requisite relief until the next ensuing meeting of the general committee.

All requests for relief, or annuities, are forwarded to the general committee, through the owners or the manager of the mine at which the accident occurred, and must be accompanied by the following documents:

1. Their opinion of the value of the request.

2. The certificate of the colliery surgeon as to the cause of death, or the nature of the wound.

3. The certificate of a magistrate in all fatal cases.

4. Copies of certificates of marriage and registration of the children, or other heirs of the deceased or disabled miner.

5. Certificate that relief is being provisionally administered by the branch fund.

6. Extract from pay sheets in which such relief is entered.

7. Statement of the foreman, or manager, of the mine, as to the cause of the accident.

8. Statement of the workmen witnesses of the accident.

To these the surgeon of the Association must append his report.

Every year the general committee summons a general meeting of the Association, before which the report is laid and adopted. The meeting then proceeds to the sanction of the measures recommended by the committee for the disposal of the funds, and the reëlection of the members of the committee. Each associated mine has one vote for every 300 men employed at it. No alteration can be made to any of the rules, save at a general meeting convened for the purpose by the general committee; and all rules, and amendments, or alterations of rules, must be submitted to the King of the Belgians for approval and sanction.

Operations of the Association in 1860.—Having now explained, to the best of my power, the constitution and the leading features of the Association, I shall proceed to give a short summary of its financial operations, the statistics and figures thereof being extracted from the Annual Report of the General Committee for the year 1860—premising that the Society has been gradually but steadily increasing since that period.

Thirty-one of the most important mines and establishments of the province of Hainaut, have become associated to the Fund. These mines employ, altogether, 22,337 workmen; to whom, in 1860, the amount of £699,206 was paid as wages for 6,908,245 days' works, at an average per man, *per diem*, of 2s. 0¼d. The following table shows the comparison between 1860 and the six preceding years:—

Year.	Wages.	No. of Men employed.	Number of Days' Works.	Average per Working Day
	£ s. d.			s. d.
1854	573,160 6 0	20,942	6,487,173	1 9·24
1855	739,284 9 0	22,941	7,047,609	2 1·15
1856	671,350 6 0	21,443	6,586,375	2 0·48
1857	588,900 1 8	20,942	6,426,202	1 9·98
1858	650,208 13 7	21,869	6,767,162	1 11·04
1859	717,714 4 0	23,049	7,121,556	2 0·19
1860	699,206 10 0	22,337	6,908,245	2 0·29

The receipts of the fund, for 1860, were as follows:—

	£	s.	d.
1.—Contribution from the Minister of Public Works ...	£520	0	0
2.—Contribution from the Province	100	8	9
3.—Contribution from the Society of Encouragement of National Industry	200	0	0
4.—¾ per cent. on the workmen's wages	5244	0	11
5.—Similar sum paid by owners	5244	0	11
6.—Interest at 4 per cent. on Bonds of the Société Générale	472	3	3
7.—Interest at 4½ per cent. on Belgian Loan	682	10	0
8.—Interest on Provincial Bonds	38	10	0
	£12,501	13	10

And in the same year the payments were—

1.—Annuities and relief for all cases of accident (see Appendix A)... ...	£10,375 3 2	
2.—Annuities to superannuated and helpless old workmen	203 17 6	
		10,579 0 8
3.—Educational grants (see Appendix C)		700 0 0
4.—Expenses of management, &c.		307 17 0
		£11,586 17 8
Which, being deducted from the total receipts, as above...		12,501 13 10
Leaves a balance on hand of		£914 16 2
Which, added to the amount of funds at the credit of the Association at 31st December, 1859		31,902 0 10
Makes the total assets of the Fund		£32,816 17 0

The total number of annuities at the termination of 1859 was 2405, of which 1371 became extinct in 1860, leaving at the end of that year 1034 names inscribed as claimants on the books of the Association, which are classed as under:—

395	widows of workmen, receiving each	£8	15	2	or ...	£3460	4	0
23	„ foremen „	9	19	$6\frac{1}{4}$	......	229	9	0
20	infirm workmen „	8	15	2	......	175	4	0
2	„ „ „	7	13	11	......	15	7	10
1	master workman „	9	19	$6\frac{1}{4}$	......	9	19	6
45	men above 70 „	4	16	0	......	216	0	0
9	widows of do. „	4	16	0	......	43	4	0
397	orphans of workmen „	1	15	$1\frac{1}{2}$	......	695	10	11
19	„ of foremen „	1	17	8	......	35	12	2
78	„ whose annuities will cease in 1861 „		—		......	65	0	2
31	fathers, mothers, and daughters „	8	15	2	......	271	11	3
6	fathers and mothers „	4	19	9	......	29	18	7
2	daughters „	4	7	7	......	8	15	2
1	daughter of foreman „	9	19	$6\frac{1}{4}$	......	9	19	6
2	fathers and mothers of foremen „	4	16	0	......	9	12	0
1	mother „	6	4	9	......	6	4	9
1	Ditto „	4	16	0	......	4	16	0
1	Ditto „	4	0	0	......	4	0	0
1034						£5290	8	10

In 1860, ten widows received the allowance of £14 12s. each, allotted by the general committee. The total amount paid as marriage portion, from the commencement of the fund up to January, 1861, was—

132	widows of workmen, each £14 12s. or	£1927	4	0
6	„ of foremen, each £17 0s. 8d. or	102	4	0
138		£2029	8	0

The next point to which it may be interesting to allude, is the number and nature of accidents which occurred in 1860, in the mines associated to the fund, and which are thus classed in the report :—

17 from falls of stone, coal, &c.
9 burnt by explosive gases.
10 from falling down shafts.
2 run over by coal tubs and wagons.
5 from explosion of gunpowder and blasting.
2 in shafts.
1 from accidental fall.
3 from the bursting of a boiler.
2 from carbonic acid gas or "stythe."
4 cases of *hernia*.
6 from sundry causes.

61

Of these there were 30 married men, with families, killed, and 11 wounded; 13 unmarried men killed, and 3 wounded; and 4 women killed (women being still employed in some of the work incidental to collieries in Belgium).

The table appended (B) shows the distribution of the sums set apart for education, and the average cost per miner per annum, which average, taken on the last nine years, only amounts to $2\frac{1}{3}$d. The three classes of schools of the friars *(frères)*, the nuns *(sœurs)*, and the lay schools, all participate in the sum voted by the general committee, and in 1860 imparted instruction to 9708 children, of whom 7703 were educated gratuitously, the remainder paying a very trifling sum as fees.

The expenses of management were, in 1860:—

	£	s.	d.
1.—Copying minutes of general meetings	£12	0	0
2.—Office expenses, including auditor's and secretary's expenses	68	0	0
3— Salary of the surgeon attached to the fund	120	0	0
4.—Printing, stationery, &c.	40	9	5
5.—Postages, &c.	33	6	3
6.—Paid to the workmen, members of general committee, for attendance at meetings	14	8	0
7.—Provincial agents expenses	14	15	4
8.—Law expenses	4	18	2
Total	£307	17	2

This total is remarkably moderate, when the magnitude and extent of the transactions of the fund are considered; and a good lesson might be learnt from it by many associations and societies in this country, in which a very large proportion of the profits are swallowed up in costly, and sometimes wasteful expenses of management.

The total receipts and payments of the fund, from the date of its establishment, in 1841, to the 31st December, 1860, may be thus tabulated:—

RECEIPTS.

	£	s.	d.
1.—Per centage on workmen's wages, and sum paid by owners	£121,610	15	5
2.—State grants	13,092	0	0
3.—Provincial grants	2,630	1	11
4.—Contribution from the Society of Encouragement of National Industry	4,000	0	0
5.—Interests on monies	11,922	6	11
6.—Sundry receipts	167	16	0
7.—Legacies and donations	36	15	1
Total receipts ...	£153,459	15	4

Total receipts brought forward				£153,459	15	4
Payments.						
1.—Annuities and relief	£105,674	10	0			
2.—Grants to the Communal Districts for education	9,321	0	0			
3.—Grants to the Society of St. Jean François Régis	32	0	0			
4.—Expenses of management	4,349	0	2			
5.—Treatment of miners suffering from *hernia*	1,266	8	2			
				120,642	18	4
Total assets of Fund, as previously stated				£32,816	17	0

In conclusion, I shall merely allude to the branch funds, as space and time will not allow for any very detailed description of their financial transactions. The following are the most interesting points embodied in the report.

Of the 31 branch funds of the Association, two balanced exactly the receipts by the disbursements, sixteen had a deficit, and thirteen a surplus. (See appendix C.)

The total number of miners temporarily relieved by the branch funds was 8523, who had the following sums allotted them, viz.:—

					Per man.
In money	£4538	16	3	=	10s. 7¾d.
In medicines, &c.	338	4	0	=	9½d.
In coal	506	17	2	=	1s. 2¼d.
In sundry articles, bedding, wine, food, &c....	422	5	7	=	1s. 0d.
Total ...	£5806	3	0	=	13s. 7½d.

The total receipts of these branch funds in 1860 amounted to £9568 16s. 8d., towards which each of the 22,337 associated workmen contributed 8s. 6¾d., the balance being furnished by the owners.

I have now shown the leading features of a fund unrivalled in the magnitude and extent of its operations; and before concluding this, I fear, somewhat dry analysis, I must take the opportunity of conveying my thanks to Mons. A. Van Waeyenberch, formerly of Hainaut, and now resident in Newcastle, who has assisted me, in many ways, in procuring the necessary information for this notice; which, however, is not so complete as I could have wished, owing, principally, to the difficulty of obtaining recent official reports of the *Caisse de Prévoyance.* I trust I may have made apparent the many advantages embodied in this Association, which stands preëminent for its practical working and useful results; and, finally, I must express the hope that we may be enabled to engraft on our mining system a similar institution; which, by the assistance it renders to the miner when disabled, and the education it provides for his offspring, creates good feeling between masters and men, and may eventually eradicate the tendency to those injurious and misguided *strikes* for which our country is unfortunately so notorious.

APPENDIX A.

Showing the Amounts and Distribution of Annuities and Relief in 1859 and 1860, for all Cases since the Commencement of the Fund.

Year in which Relief was first afforded.	Widows.		Incurable Workmen.		Parents, &c., of Workmen.		Orphans.		Wounded Workmen.		Workmen over 70 Years of Age.		Total Sums paid.			Difference.	
	No.	Amount.	No.	Amount.	No.	Amount.	No.	Amount.	No.	Amount.	No.	Amount.	No.	1860.	1859.	Increase.	Decrease.
		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.	£ s. d.	£ s. d.	£ s. d.
1840	5	45 0 3	1	8 15 3	1	8 15 3	..	....	2	15 8 3	..	....	9	77 19 0	77 19 0	....	....
1841	7	63 15 7	1	8 15 3	..	....	..	....	1	6 4 10	..	....	9	78 15 8	89 5 1	....	10 9 5
1842	9	80 1 2	..	....	..	....	2	3 12 6	7	61 6 4	..	....	18	145 0 0	145 0 0	....	....
1843	4	36 5 4	..	....	..	....	..	....	10	85 15 3	..	....	14	122 0 7	116 6 11	5 13 8	....
1844	10	87 12 0	..	....	..	....	..	....	10	87 12 0	..	....	20	175 4 0	184 9 9	....	9 5 9
1845	13	107 15 9	..	....	7	59 0 5	..	....	15	128 15 3	..	....	35	295 11 5	325 4 1	....	29 12 8
1846	15	130 18 3	2	17 10 6	3	18 19 7	..	....	11	90 4 2	..	....	31	257 12 6	265 17 11	....	8 5 5
1847	16	139 11 9	1	8 15 3	..	....	3	1 3 9	19	164 16 11	..	....	39	314 7 8	340 7 4	....	25 19 8
1848	9	79 2 9	..	....	3	13 11 2	3	5 19 6	19	162 2 4	..	....	34	260 15 9	266 7 8	....	5 11 11
1849	15	132 12 4	1	8 15 3	1	8 15 3	7	9 0 10	20	139 10 11	..	....	44	298 14 7	328 4 0	....	29 9 5
1850	15	125 1 5	2	17 10 6	2	18 14 8	18	53 19 4	28	241 4 3	..	....	65	456 10 2	487 18 7	....	31 8 5
1851	13	113 17 7	1	8 15 3	4	19 8 9	21	39 8 2	41	356 3 5	..	....	80	537 13 2	576 7 9	....	38 14 7
1852	35	302 0 8	..	....	4	19 10 6	62	77 16 11	25	209 19 4	..	....	126	609 7 5	736 17 1	....	127 9 8
1853	33	306 2 4	..	....	8	58 8 3	40	59 6 0	34	299 2 10	..	....	115	722 19 5	780 18 4	....	57 18 11
1854	22	189 16 1	..	....	7	41 6 4	32	45 19 8	36	315 3 6	..	....	97	592 5 7	685 4 10	....	92 19 3
1855	28	233 19 0	1	8 15 3	5	28 8 5	44	58 13 1	42	346 3 4	..	....	120	675 19 1	812 19 1	....	137 0 0
1856	43	386 11 8	1	5 6 4	1	4 16 0	69	88 4 9	42	353 18 10	13	54 11 5	169	893 9 0	1029 0 9	....	135 11 9
1857	34	318 0 0	4	26 5 7	2	17 10 6	62	96 1 3	74	621 1 3	3	8 0 0	179	1036 18 7	1122 8 2	....	35 9 7
1858	44	426 7 11	4	35 0 9	7	50 18 3	67	97 12 5	84	735 17 4	13	65 6 1	219	1411 2 9	1415 15 4	....	4 12 7
1859	49	422 4 3	4	28 14 11	14	54 0 4	107	174 13 9	73	561 3 8	8	34 8 0	255	1275 4 11	385 6 5	889 18 6	....
1860	30	99 0 2	1	5 16 8	31	44 10 8	49	31 17 11	13	68 12 0	12	41 12 1	136	291 9 6	....	291 9 6	....
Totals..	449	3825 16 3	24	188 16 9	100	466 14 4	586	843 9 10	606	5050 6 0	49	203 17 7	1814	10579 0 9	10171 18 1	1187 1 8	779 19 0

APPENDIX B.

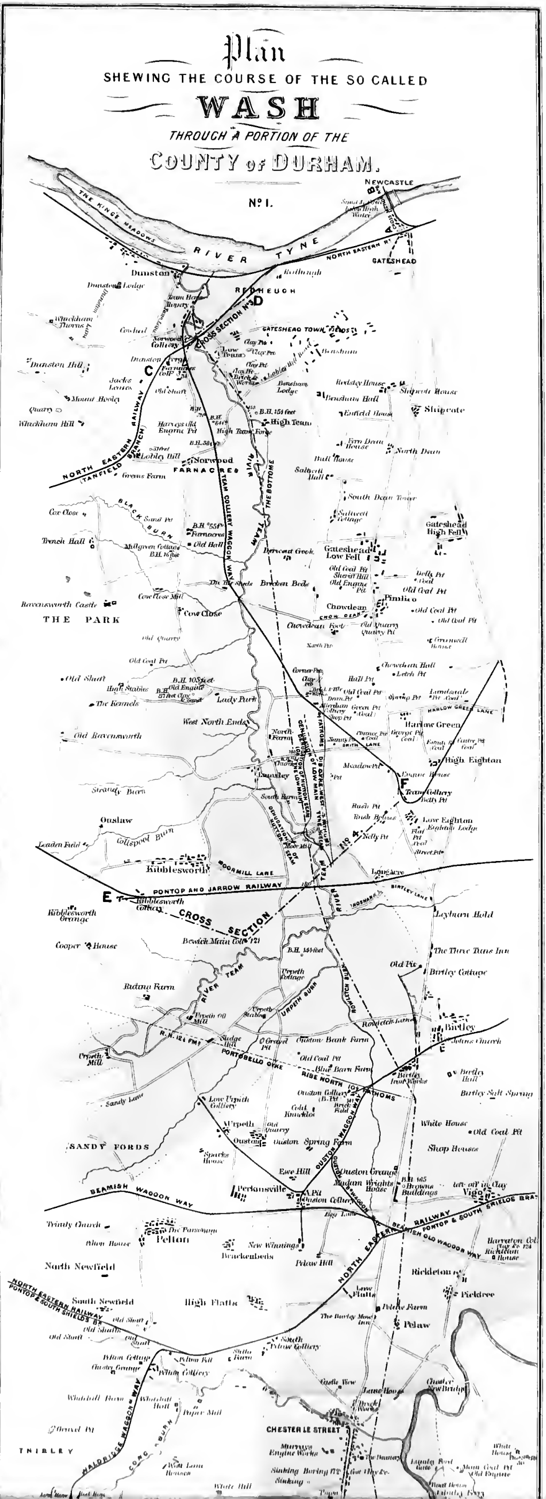
Showing the Amounts and Distribution of the Funds allotted to the Education of the Miners' Children.

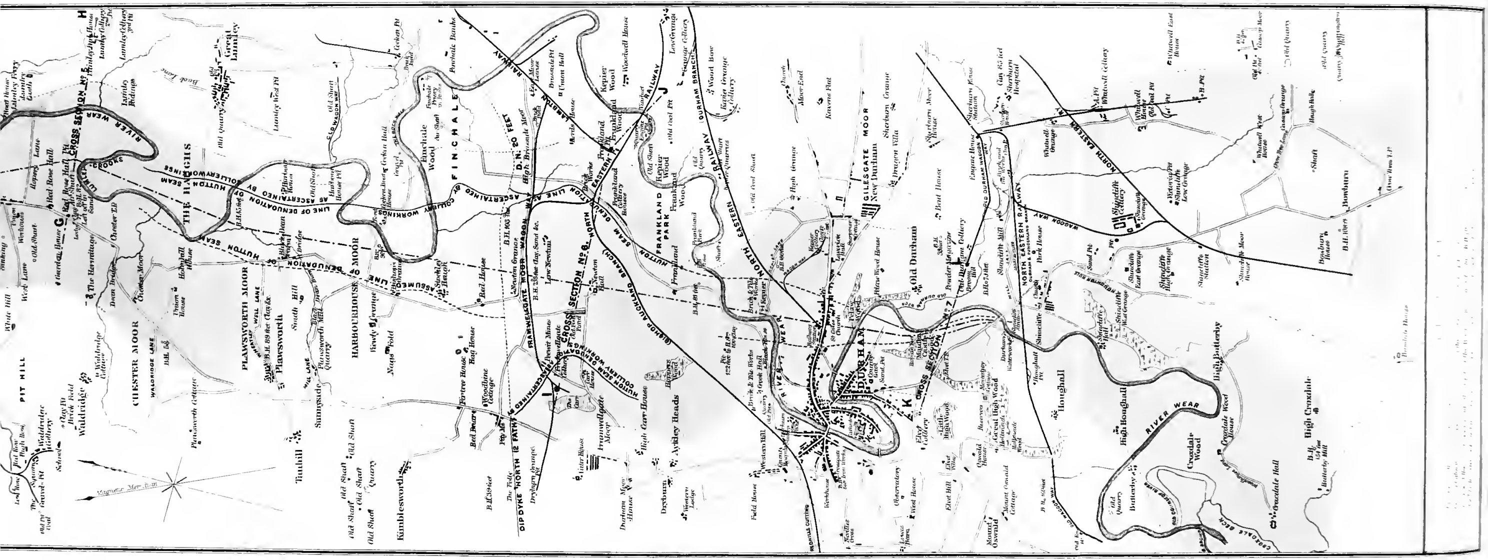
Year.	Contributions (Subsides). Ordinary.	Extra-ordinary.	Total.	By whom Contributed. Subscriptions of Owners.	Subscriptions of Workmen.	Grant of the Societe Generale.	Total.	To whom Delivered. Christian Schools of the Freres.	Do., of the Nuns.	Lay Schools.	Total.	No. of Workmen.	Distribution of Workmen's Subscriptions among the Schools. The Freres.	Average in Pence per workman.	The Nuns.	Average in Pence per Workman.	Lay Schools.	Average in Pence per Workman.	Total.	General Average in Pence per Workman per annum.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.		£ s. d.	d.	£ s. d.	d.	£ s. d.	d.	£ s. d.	s. d.
1852	401 0 0	64 0 0	465 0 0	132 10 0	132 10 0	200 0 0	465 0 0	173 0 0	130 0 0	162 0 0	465 0 0	17045	36 10 0	½	15 0 0	¼	81 0 0	1¼	132 10 0	0 2
1853	467 0 0	38 0 0	505 0 0	152 10 0	152 10 0	200 0 0	505 0 0	140 0 0	250 0 0	115 0 0	505 0 0	18585	20 0 0	⅜	75 0 0	1	57 10 0	⅝	152 10 0	0 2
1854	454 0 0	114 2 10	568 2 10	184 1 5	184 1 5	200 0 0	568 2 10	246 2 10	248 0 0	74 0 0	568 2 10	20942	73 1 5	⅞	74 0 0	1	37 0 0	⅜	184 1 5	0 2¼
1855	534 0 0	24 0 0	558 0 0	179 0 0	179 0 0	200 0 0	558 0 0	246 0 0	242 0 0	70 0 0	558 0 0	22941	73 0 0	¾	71 0 0	¾	35 0 0	½	179 0 0	0 2
1856	590 0 0	12 0 0	602 0 0	201 0 0	201 0 0	200 0 0	602 0 0	279 4 0	242 0 0	80 16 0	602 0 0	21443	89 12 0	1	71 0 0	¾	40 8 0	½	201 0 0	0 2¼
1857	550 0 0	90 0 0	640 0 0	220 0 0	220 0 0	200 0 0	640 0 0	266 0 0	279 4 0	94 16 0	640 0 0	20942	83 0 0	1	89 12 0	1	47 8 0	½	220 0 0	0 2½
1858	560 0 0	72 16 0	632 16 0	216 8 0	216 8 0	200 0 0	632 16 0	270 0 0	260 16 0	102 0 0	632 16 0	21869	85 0 0	1	80 8 0	1	51 0 0	½	216 8 0	0 2¼
1859	632 8 0	74 16 0	707 4 0	253 12 0	253 12 0	200 0 0	707 4 0	280 0 0	312 0 0	115 4 0	707 4 0	23049	91 0 0	1	106 0 0	1¼	56 12 0	½	253 12 0	0 2¾
1860	660 0 0	40 0 0	700 0 0	250 0 0	250 0 0	200 0 0	700 0 0	330 0 0	272 0 0	98 0 0	700 0 0	22337	115 0 0	1¼	86 0 0	1	49 0 0	½	250 0 0	0 2¼
Total ..	4848 8 0	529 14 10	5378 2 10	1789 1 5	1789 1 5	1800 0 0	5378 2 10	2230 6 10	2236 0 0	911 16 0	5378 2 10	189153	666 3 5	7¾	668 0 0	8	454 18 0	5¼	1789 1 5	1 9
Average £	538 14 2⅔	58 17 2⅓	597 11 5	198 15 8½	198 15 8½	200 0 0	597 11 5	247 16 4	248 8 10⅔	101 6 2⅓	597 11 5	21017	74 0 5	⅞	74 4 5	⅞	50 10 10½	$\frac{7}{12}$	198 15 8½	2⅓

APPENDIX C.

Showing Receipts and Payments of the several Branch Funds of the Association in 1860.

No.	Name of Fund.	Receipts.	Proportion per cent. of Wages paid.	Payments. Expenses of Management and Medical Agency.	Payments. Delivered in Medicine.	Payments. Delivered in Coal.	Payments. Delivered in Sundries.	Payments. Relief to the Wounded.	Payments. Extraordinary Relief and Annuities.	Payments. Education of Children.	Payments. Total.	Balance. Plus.	Balance. Minus.	No. of Men Wounded and Relieved.
		£ s. d.		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
1	Grand Hornu	539 13 3	1·14	381 10 3	151 6 0	28 16 8	282 0 2	172 6 11	231 10 6	245 1 5	1492 11 11	..	952 18 8	663
2	Grand Buisson	152 17 4	·55	144 10 6	26 10 9	9 6 3	..	125 4 7	77 19 7	..	383 11 8	..	230 14 4	332
3	Boussu and St. Croix St. Claire	210 5 4	·5	124 0 0	2 15 7	92 9 2	1 6 10	160 18 9	1 4 2	31 4 11	413 19 5	..	203 14 1	407
4	Bois	87 17 2	·5	84 6 9	..	6 17 7	3 18 10	76 19 4	..	..	172 2 6	..	84 5 4	107
5	Centre du Flenu	64 2 2	1·15	32 0 0	..	2 0 0	..	92 12 7	6 4 10	..	132 17 5	..	68 15 3	185
6	Levant d'Elonges	193 12 8	1·08	104 0 0	6 13 10	7 4 0	..	99 11 5	22 2 6	..	239 11 9	..	45 19 1	167
7	Railways of the Flenu	111 9 7	1·25	40 0 0	2 10 3	0 7 8	7 12 1	37 3 6	22 0 0	46 0 0	155 13 6	..	44 3 11	28
8	Couchant du Flenu	903 5 11	1·70	186 17 6	24 17 3	19 1 5	23 1 11	630 1 7	4 8 10	48 0 0	936 8 6	..	33 2 7	915
9	Bellevue, Baisieux, &c.	461 9 3	1·75	128 0 0	14 17 3	9 3 3	4 12 8	133 19 3	186 8 10	16 0 0	493 1 3	..	31 12 0	532
10	Midi du Flenu	130 17 0	1·	61 6 2	4 2 9	13 18 5	..	65 16 11	13 3 5	..	158 7 8	..	27 10 8	171
11	Seize-Actions	77 3 7	·75	46 0 0	1 16 0	3 10 5	..	41 7 7	4 0 0	..	96 14 0	..	19 10 5	60
12	Bas-Flenu	141 4 8	·95	24 0 0	4 18 2	6 14 5	1 8 10	108 8 6	14 6 8	0 9 7	160 6 2	..	19 1 6	184
13	Saint-Amand	9 2 10	·52	9 2 11	..	..	..	10 16 0	..	..	19 18 11	..	10 16 1	45
14	St. Ghislain Railway	25 15 1	1·	17 1 5	3 17 8	..	..	3 13 0	9 12 0	..	34 4 1	..	8 9 0	3
15	Rien-du-Cœur	13 17 9	·75	..	..	..	..	16 17 9	1 18 5	..	18 16 2	..	4 18 5	3
16	Produits	765 15 9	1·08	164 0 0	..	49 11 8	10 6 10	444 9 7	..	98 0 0	766 8 1	..	0 12 4	641
17	Agrappe and Grisœuil	1377 0 3	2·25	188 0 0	..	3 15 7	26 7 3	730 17 0	..	26 12 10	975 12 8	401 7 7	..	514
18	Escouffiaux	610 17 5	2·21	119 0 0	6 12 10	3 3 4	2 5 7	220 1 4	..	..	351 3 1	259 14 4	..	212
19	Crachet-Picquery	399 2 2	2·2	62 0 0	3 8 7	12 13 2	0 14 9	119 4 4	2 16 9	35 17 4	236 14 11	162 7 3	..	306
20	Levant du Flenu	548 0 5	1·28	117 17 7	..	22 6 11	7 12 7	294 17 1	..	49 11 3	492 5 5	55 15 0	..	406
21	Cipley Coal Co.	56 5 3	3·07	10 19 10	..	..	..	0 6 5	1 2 2	..	12 8 5	43 16 10	..	1
22	United Coal Co.	265 14 8	1·9	72 7 3	16 4 2	2 19 2	0 19 6	114 1 4	18 12 0	..	225 3 5	40 11 3	..	259
23	Chevalieres and Midi de Dour	120 16 5	1·25	48 7 9	5 2 4	2 10 2	..	25 6 7	9 4 9	..	90 11 7	30 4 10	..	160
24	Bonne-Esperance and Bonne-Veine	379 16 11	1·25	128 0 0	19 6 0	20 16 0	4 7 9	192 10 4	3 8 0	..	368 8 1	11 8 10	..	636
25	Longterne-Ferrand	257 7 10	1·35	120 4 5	5 4 4	0 18 3	10 14 1	106 18 8	2 16 10	..	246 16 7	10 11 3	..	197
26	Sawartan	165 14 3	1·21	64 9 7	1 15 5	10 8 1	5 13 9	69 14 6	8 0 3	..	160 1 7	5 12 8	..	71
27	Haut Flenu	461 16 10	1·3	113 0 0	8 0 0	46 7 8	5 4 2	157 11 7	41 12 0	84 0 0	455 15 5	5 11 5	..	356
28	Hornu and Wasmes	884 10 7	1·75	200 13 3	23 5 9	127 5 8	18 13 7	231 14 9	275 11 11	1 19 2	879 4 1	5 6 6	..	824
29	Grande Veine	56 16 3	1·5	28 9 9	3 5 6	3 8 3	1 18 11	17 6 11	..	..	54 9 4	2 6 11	..	28
30	Longterne-Tricheres	50 5 4	·81	16 0 0	1 13 7	1 4 0	3 5 6	25 9 10	2 12 4	..	50 5 3	..	..	75
31	Petite-Sorciere	46 12 10	1·	34 4 6	..	..	..	12 8 4	..	..	46 12 10	..	..	35
		9568 16 8	1·36	2870 9 5	338 4 0	506 17 2	422 5 7	4538 16 3	960 16 9	682 16 6	10320 5 8	1034 14 8	1786 3 8	8523


Plan
SHEWING THE COURSE OF THE SO CALLED
WASH
THROUGH A PORTION OF THE
COUNTY of DURHAM.
No. I.
NEWCASTLE
GATESHEAD
RIVER TYNE
NORTH EASTERN RY.
THE KINGS MEADOWS
REDHEUGH
Dunston
CROSS SECTION No. 3
GATESHEAD TOWN FIELDS
NORTH EASTERN RAILWAY (TANFIELD BRANCH)
NORWOOD FARNACRES
TEAM COLLIERY WAGGON WAY
RIVER TEAM
THE BOTTOMS
High Team
Shipcote
Gateshead High Fell
Gateshead Low Fell
THE PARK
Ravensworth Castle
Chowdean
Lady Park
West North Ends
Harlow Green
High Eighton
Low Eighton
Kibblesworth
PONTOP AND JARROW RAILWAY
CROSS SECTION
Leyburn Hold
Birtley
Birtley Salt Spring
SANDY FORDS
BEAMISH WAGGON WAY
Ouston
Perkinsville
Vigo
Pelton
High Flatts
North Newfield
South Newfield
NORTH EASTERN RAILWAY PONTOP & SOUTH SHIELDS BR.
NORTH EASTERN RAILWAY PONTOP & SOUTH SHIELDS BRA.
Rickleton
Picktree
Pelaw
CHESTER LE STREET
TRIBLEY


DURHAM
RIVER WEAR
CROSS SECTION No. 5
CROSS SECTION No. 6
CROSS SECTION No. 7
FINCHALE
THE HAUGHS
GILESGATE MOOR
FRANKLAND PARK
HARBOURHOUSE MOOR
PLAWSWORTH MOOR
CHESTER MOOR
PIT HILL
NORTH EASTERN RAILWAY
Old Durham
Houghall
Kimblesworth
Plawsworth

ON A "WASH" OR "DRIFT"

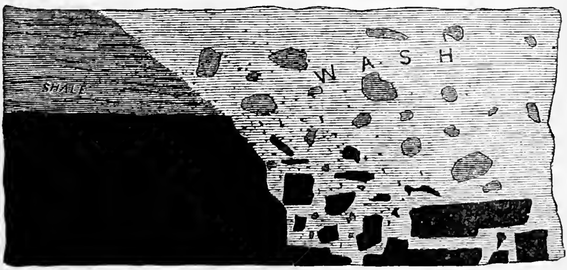
THROUGH A

PORTION OF THE COAL-FIELD OF DURHAM.

By NICHOLAS WOOD & EDWARD F. BOYD.

The present surface of the earth everywhere exhibits proofs of a universal deluge of waters having passed over it, or that it has been subjected to the action of water, either comparatively still in its progress, or in the shape of currents of more or less intensity; and it would appear that this did not take place until after all the different varieties of strata, of which the then surface of the globe consisted, had been consolidated, and had exhibited a greater or less degree of hardness and solidity. We observe that every part of the surface of the globe has been so affected; whether at a low elevation in the valleys, or on the tops of the highest hills, every part exhibits the action of water, the abrasion of the solid strata, and the formation of sand, gravel, and rounded boulders of greater or less dimensions, as the velocity of the currents acted with greater or less force in the distribution of them; and here and there along the present valleys, or what may be supposed to have been the valleys of that period, we find indications that these valleys have been scooped out much below the high-water mark of the existing seas by the powerful action of running water, or by the glacial action of moving ice. We do not know how to account for such a quantity of water as would be necessary, in the first place, to effect the abrasion of the solid strata to the extent required to produce such a quantity of gravel, sand, or clay, as appears to cover the present surface of the globe. The action of floods, produced by the ordinary causes of atmospheric influences, do not appear to us to account for such effects. We only know the fact that such abrasions have taken place; that such a covering exists; that it is universal; and that it is of various thicknesses in different situations, and even forms hills of considerable elevation in some parts of the globe. Likewise, we do not attempt to explain the causes which have produced the shales, the sandstones, or the conglomerates of former periods, which compose the now solid strata of the globe; nor to investigate if what is now taking place in the present distribution of sea and land, and subjected to existing atmospheric influences, and likewise differing in degree, is capable of producing a continuation of what has taken place in past time. We admit that the agencies now at work are sufficient, in time, to modify the surface of the globe, to scoop out valleys, to wear down hills, to fill up lakes, estuaries, and even seas. That such agencies of wasting and wearing down, and eroding the rocky surface of our globe, and carrying such eroded materials to considerable distances, and spreading them over the bottom of the sea, do exist; and that these materials may be consolidated and again form solid strata, and produce the beds of shale, sandstone, and conglomerates of a subsequent period, and that volcanic or other forces may elevate them into dry land, and form new mountain chains, etc., are the conclusions of geologists. Admitting such to be the case, there are some of the phenomena exhibited to us by the mining operations of this district, which we think most materially bear upon such theories. And as, we presume, it is one of the objects of the British Association, in its peregrinations to different parts of the kingdom, to elicit scientific facts, and to collect local information, we consider it our duty to present some of the results of our observations connected with the phenomena in question, and to contribute our mite of scientific information in aid of the general object of the Association. In the prosecution of our professional duties, we have had many opportunities of collecting information relative to the thickness of the covering of gravel, sand, and clay spread over the surface of the coal-field of Durham — more particularly as it occurs in various situations, and under different circumstances; and also frequent opportunities of observing the denudation and abrasion of the mineral strata of the district, and especially of a particular "Wash" or "Drift" in the coal-field of Durham, which has denuded a considerable portion of the Coal-measures. Premising, then, that such a Wash or Drift can be distinctly traced through the coal-field from the vicinity of the city of Durham to the river Tyne at Newcastle, traversing a portion of the valley of the Wear, passing Chester-le-Street, and following the valley of the Team to its junction with the river Tyne, we beg to lay before the Association the result of our observations thereon.

An examination of the different cross sections accompanying this paper, particularly those nearest to the river Tyne, clearly shows that the deepest portion of the denudation was on the eastern side, and that, consequently, the edges of the strata on that side are more upright and abrupt. No trace whatever, in any part of its course, has been, to our knowledge, found of shells, bones, or animal remains. Those pieces of shale which were observed entire, and resting on edge against the eastern side of the Wash, appear to have been comparatively recently broken from their stratified bed, and they would, no doubt, contain, if examined, the usual fossil ferns and plants of the Carboniferous period. All the stones and pebbles having their edges entirely rounded and rendered smooth (particularly those of a harder nature), bear evidence of long exposure to the abrasive influence of large bodies of running water. It must not be omitted also to record, that whenever opportunity exposed the bottom or surface on which the boulder-clay rests, there were to be observed unmistakeable evidence that the water which carried the *debris* was in motion, and of great power. At the sinking of the Ouston B pit, the first solid strata met with after sinking through the twenty-three and a half fathoms of clay and sand, was a strong sandstone, the upper surface of which was furrowed and polished in rough and scored outlines, as may be noticed in the exposed bed of a mountain torrent passing over a hard rock. The edges of the exposed coal seams adjoining the denudation, as those ot the Hutton-seam at Harbour House and Frankland and the Main-coal seam at Urpeth, were worn and rounded off, as if acted on by the movement across them of harder bodies, carried in suspension by water moving at considerable speed and power. In some instances where the seam was traced to its extremity, it was observed that the upper portion of the seam being tenderer, had given way to the abrading action, whilst portions of that nearer the floor remained *in sitû*—the intervening parts being filled with clay and boulders, and broken pieces of coal. These were sometimes of large size, discoloured with mud, and frequently lying vertical to their original bed amongst the clay, and mixed with the boulders and gravels, as shown in the annexed diagram.



The drawings to illustrate our communication consist of a series of plans and sections of the following character, viz. :—

Plate VIII., No. 1, is a Map of the District from the city of Durham to the river Tyne, near Newcastle.

Plate IX., No. 2, is a longitudinal Section of the Wash from the city of Durham, down a portion of the Wear and the Team Valley, to the river Tyne, at a point one mile west of the High Level Bridge at Newcastle, showing the depth to which the Wash, or glacial action, has denuded the strata throughout its course between those two points.

Plates X. to XIV. are Cross Sections, showing the space which has been occupied by the Wash, and the width of the denudation at several points in its course.

In explanation of the sections across the line of, or at right angles to the north and south direction, or longitudinal section of the "Wash," it may be proper to draw attention to those particulars which more peculiarly attach themselves to each case than to the borings or sinkings occurring between each section, and through each of which it was thought unnecessary to give a section.

Commencing the description at the *embouchure* of the "Wash" into the valley of the Tyne, or at the deepest point to which the denudation has reached in the valley of the river Team, and proceeding thence southward to the river Wear at Durham; the series of sections show the surface and underground appearances of the Wash so far as they are affected by the denudation and diluvial deposit, to the extent to which they can be ascertained; and all of them are drawn nearly at right angles to the line of its north and south direction.

Plate X., No. 3, *Cross Section.*—This section is not, however, exactly at right angles, diverging from it for the purpose of showing the comparative depths of the seams and strata at Norwood and Farnacres Collieries, and the information which their exploration afforded to the subject under consideration. High-water mark of the Tyne at Newcastle being the "datum line" adopted in the several sections, the depth of the Wash at Norwood Colliery, near the junction of the river Team with the Tyne, is 140 feet; being the point of greatest depth of the Wash yet proved below the high-water line.

It will be observed, that the Norwood Pit is sunk so much within the limits of the Wash, that it affords a good opportunity of noticing the character of it, viz., clay for a considerable distance from the surface, the lower portion of light-coloured sand, without much admixture of pebbles or boulders. The Wash is here of sufficient depth to denude the three seams of coal which are rising gradually towards the west, viz.,

Nº 2.

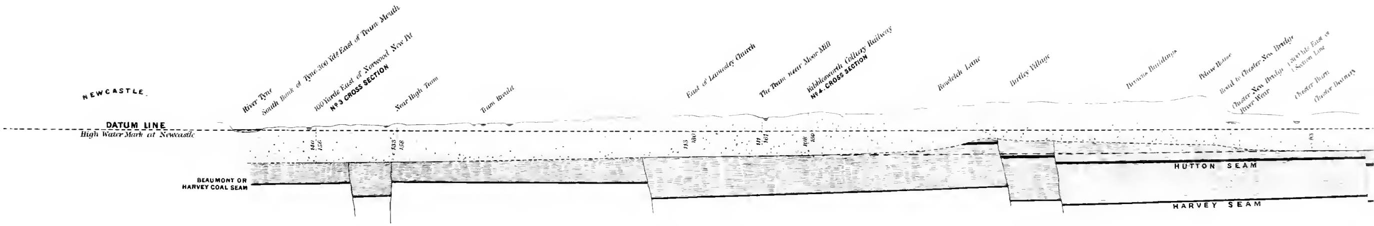
LONGITUDINAL SECTI

of the so called

WASH DEPOSI

in the line of assumed greate

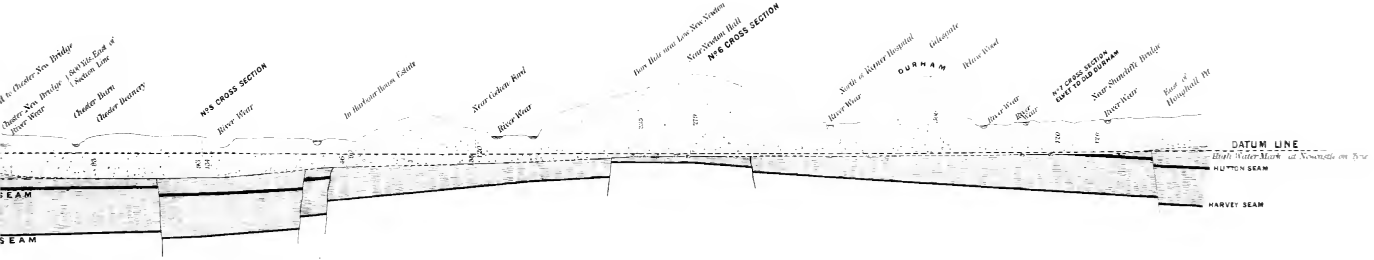
FROM THE RIVER TYNE TO A LITTLE SOUT



HORIZONTAL SCALE 2 INCHES = 1 MILE.
VERTICAL SCALE 1 INCH = 300 FEET.

NOTE

...DINAL SECTION
...the so called
...H DEPOSIT
...ssumed greatest depth
...E TO A LITTLE SOUTH OF DURHAM.



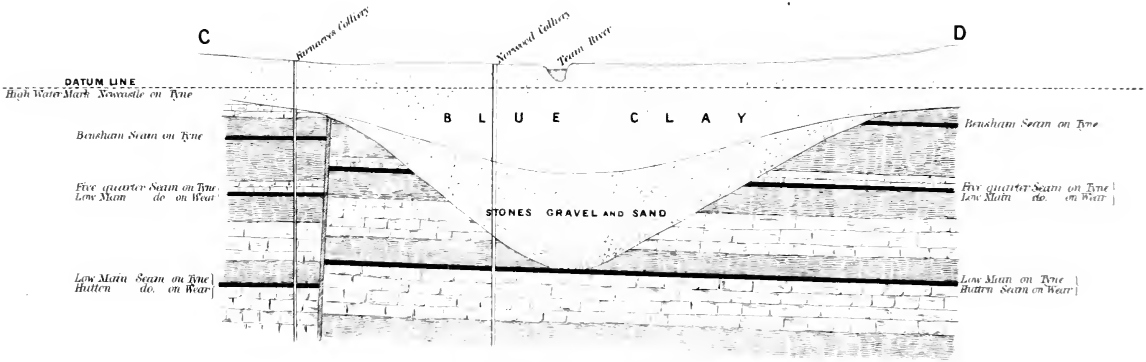
...LE 2 INCHES = 1 MILE.
...LE 1 INCH = 300 FEET.

NOTE

...and &c. Below the Datum Line
... the various ascertained points

No. 3.

CROSS SECTION NEAR MOUTH OF TEAM RIVER.



Scales

the Bensham, the Five-quarter or Low-Main of Wear; and the Low-Main or Hutton-seam of the Wear.

At the Farnacres Pit, represented in the same section, and situated 320 yards south 24° west from Norwood Pit, there is not more than 34 feet of clay, etc., it being evidently on the edge of the deep deposit. The occurrence of deep, brick-clay pits in the neighbourhood, and the section afforded by the course of the Team rivulet, attest the nature of this aluminous matter, and also that no rock is here visible.

Southwards, towards the Cross Section No. 4, we have the evidence of certain boreholes as to the thickness and direction of the deposit.

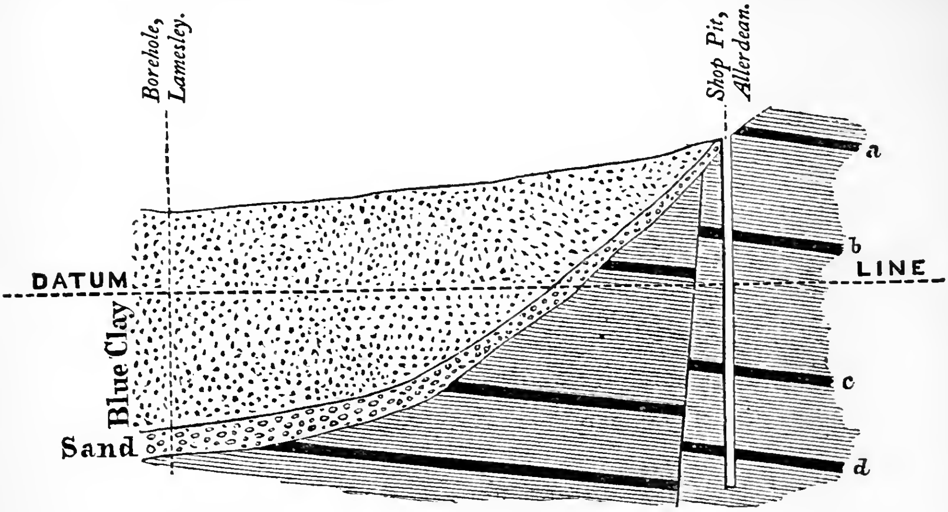
Within Field House estate, and near to Team High Forge, a borehole shows	151	feet
Adjoining the Team Colliery Railway, nearly opposite to the last-named, and near to the old Pumping Engine Pit within the Norwood, we have two boreholes, showing	84	„
And a little west	37	„
And a little farther west, adjoining Norwood Farm-house	$38\frac{1}{2}$	„
Near to Farnacres House, being a point evidently removed considerably to west of what we deem the centre of the Wash..	35	„
The rivulet of Black Burn crosses at this point, and a brick Work occurs a little to the south.		
At the Old Engine Pit, at Lady Park, we have a borehole which shows..	105	„
And another do. do. do.	97	„

of sand, clay, etc.

At Allerdean, or Team Colliery, the Shop Pit is the site of the pumping engine of that colliery; and this shaft would appear to have penetrated the surface very near to the edge of the wash; and although the neighbourhood of a dip dyke, to south-west of $4\frac{1}{2}$ fathoms, throws the seams so much deeper, yet the thickness of clay and sand here deposited shows the Hutton seam, at a depth of $29\frac{1}{2}$ fathoms or 177 feet, denuded by the wash; and for a considerable distance to the south, the workings of the colliery in this seam have been discontinued by the effect of the Wash. The depth of the wash is here 158 feet below the river Team.

A borehole to the east of Lamesley Church, put down by Mr. W. W.

Burdon, through the instrumentality of Mr. W. Barkus, Junr., proved the Wash and subsequent deposit here to be 166½ feet (see wood cut below).

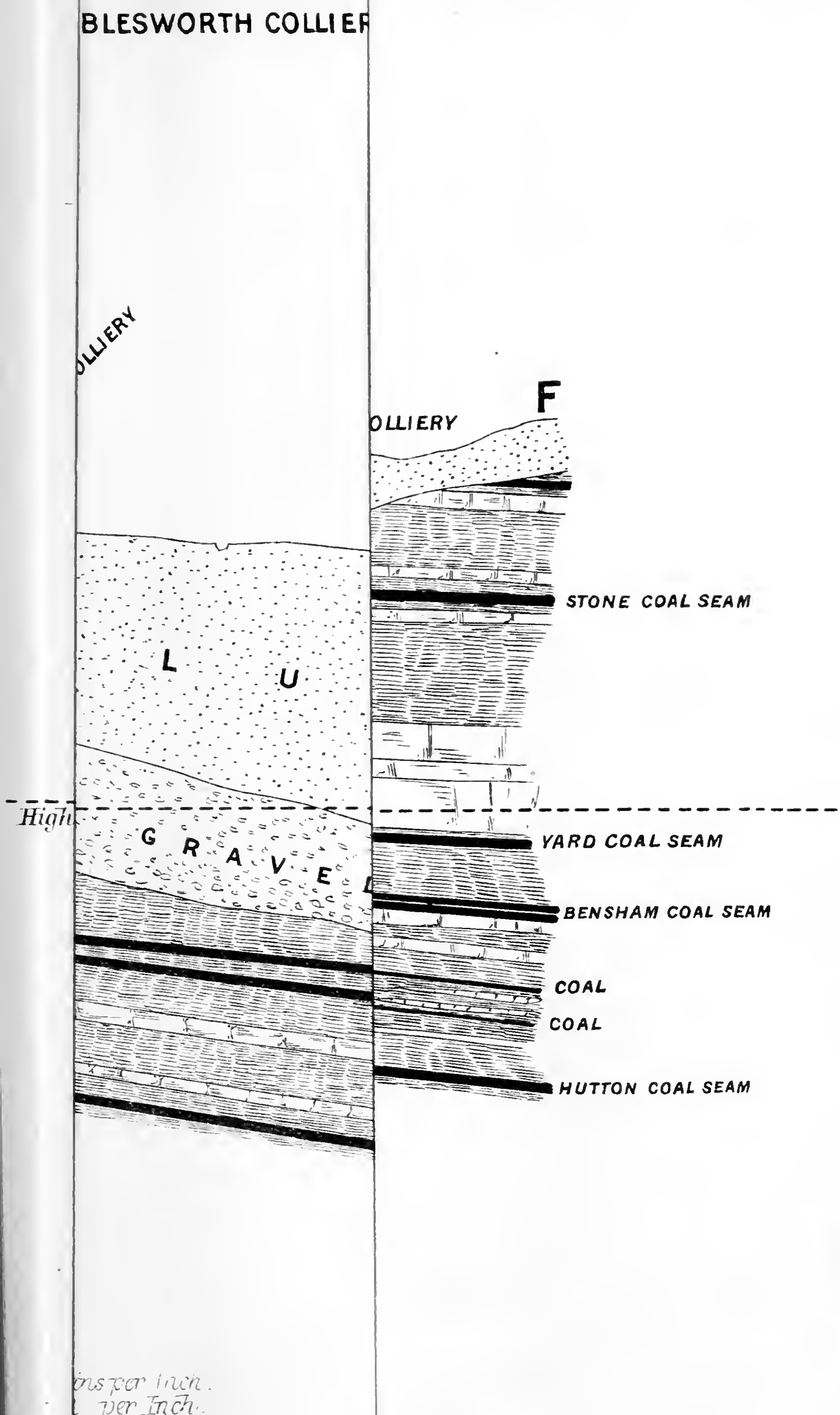


a. Yard-Coal Seam. *c. Five-quarter Seam.*
b. Bensham do. *d. Low-Main, or Hutton-Coal Seam.*

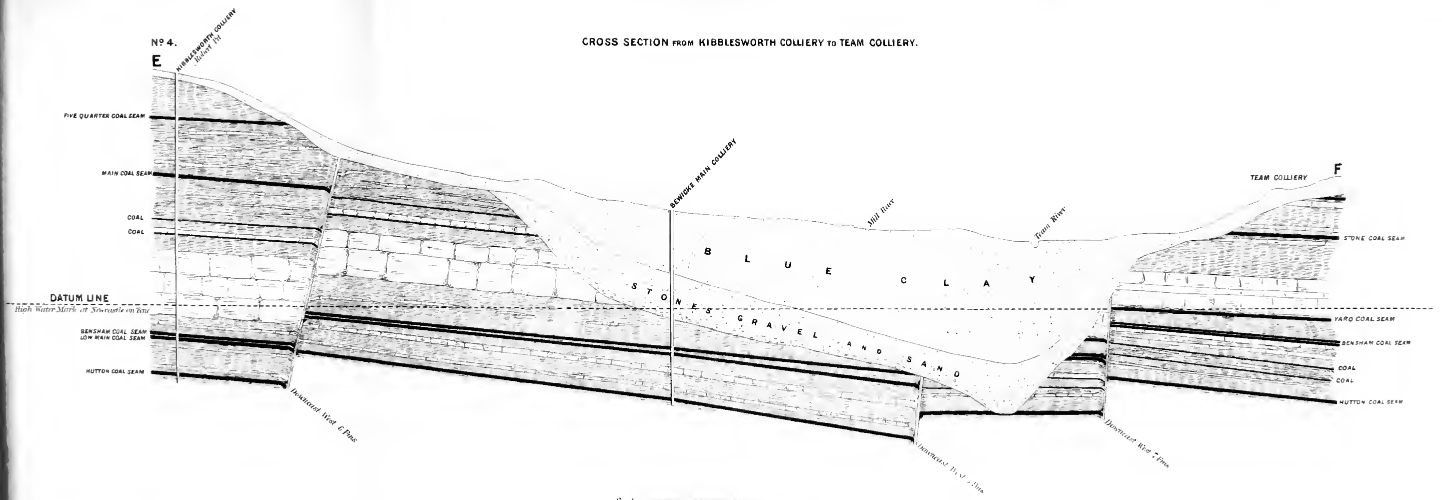
Plate XI., No. 4, *Cross Section.*—This section extending from the Team Colliery Betty Pit, and diverging slightly from a direct line in order to take in the Bewicke-main Pit (recently sunk to the Hutton-seam) and terminating at Kibblesworth Colliery, shows the same dip dyke to the west (here of seven fathoms) as that abovenamed. On the entrance to the edge of the Wash a borehole from the surface proved the thickness of the deposit to be 85 feet; but its total thickness determined by the west line of the Hutton-seam workings being denuded near the Team rivulet proved it to be 161 feet.

As a large portion of the Team royalty in the Hutton-seam, or Low-main of the Tyne, lay to the west of the Wash, it was of importance that a passage should be made through it, and the line of section given was the point at which this was accomplished. The first difficulty met with was the dip dyke of seven fathoms, requiring the heavy feeders of water (mixed with gravel and sand) flowing from the Wash to be lifted to that extent. Fortunately the floor of the seam was not penetrated by the Wash, and by means of a casement formed of stout deals, sharpened at the ends and driven forwards, the distance of 30 yards (occupied by the above-mentioned water, sand, and clay) was penetrated, and the seam discovered in its regular condition on the opposite side of the Wash.

This section shows more clearly than the other sections, that the



Lithographed by A Reid, Newcastle


No 4.
CROSS SECTION FROM KIBBLESWORTH COLLIERY TO TEAM COLLIERY.
E
KIBBLESWORTH COLLIERY
Robert Pit
FIVE QUARTER COAL SEAM
MAIN COAL SEAM
COAL
COAL
DATUM LINE
High Water Mark at Newcastle on Tyne
BENSHAM COAL SEAM
LOW MAIN COAL SEAM
HUTTON COAL SEAM
Downcast West 6 Fms
BEWICKE MAIN COLLIERY
Mill Race
Team River
BLUE CLAY
STONES GRAVEL AND SAND
F
TEAM COLLIERY
STONE COAL SEAM
YARD COAL SEAM
BENSHAM COAL SEAM
COAL
COAL
HUTTON COAL SEAM
Downcast West 7 Fms
Scales

eastern side of the denudation in which the wash is deposited is more abrupt than the western side. Mr. Barkus describes its appearance on being first approached from the east as nearly vertical, and consisting of a mass of rounded worn stones, composed of mountain limestone, millstone grit, and the shales, ironstone, and sandstones of the Coal-measures, with rare instances of the older rocks, and without any symptoms of vegetable remains, or shells, or bones.

In the same line of section at the Bewicke-main Pit, the thickness of clay and sand is 125 feet, and the sinking operations were rendered exceedingly difficult by the swelling and motion of the clay, sand, and water in sinking. Prior to reaching the regular strata, the boulders distributed in the clay and sand were found to be very large, rounded and polished, and the surface of the freestone rock first met with was grooved and striated, and presenting the appearance of being rubbed and worn by the passage of heavy material over it. As the explorings in the coal seam extend towards the bottom of the valley, symptons of fine white sand are apparent in the upright "backs" of the coal.

Proceeding southwards from Cross Section No. 4, in the Urpeth estate, at about 400 yards from the junction of the Team and Urpeth rivulets, a borehole was put down to the Hutton-seam by the then lessees of Urpeth royalty. The total depth of the deposit here is 144 feet; the uppermost 66 feet is pure unmixed blue clay; the remainder consisting of alternating layers of sand, gravel, boulders, and clay, accompanied by large feeders of water. The same difficulties arising from pressure and the motion of the clay and sand having to be contended with which rendered piping the borehole throughout the whole depth of the Wash necessary. Only seven fathoms of regular strata were left above the Hutton seam.

The two Urpeth rivulets here take a more westerly direction through a broad and undulating valley, and the circumstance of their banks—in some places of considerable thickness—being composed of sand and gravel shows the effect of the Wash in that direction. The sinking of the Urpeth New Pit, on its edge, through 63 feet of wet sand, and the Main-coal seam, at a depth of 20 fathoms in that pit, being worked up to a long line of denudation near Sledge Hill, induces the reasonable inference that this valley formed a western branch of the greater denudation of the Wash.

The record of old workings shows the western extension of Leybourne Hole Colliery from a pit at the turnpike side, 500 yards north of Birtley village to have been denuded by the "Wash" in a north and south line, about 240 yards to the west of the turnpike road leading from Newcastle to Durham.

We now approach a district where the depth of the Wash does not interfere with the Hutton seam; most probably because a large cross dyke, of 10½ fathoms dip south, called the Portobello Dyke, depresses the seam to that extent below the bottom of the Wash; and although the B pit shaft of Ouston Colliery shows 23½ fathoms, or 141 feet of sand and clay, and its workings in the Hutton seam are being extended to the east towards the turnpike on the rise side of the abovementioned dyke, and have not yet come in contact with the Wash, it is more than probable the dip of the strata to east—here regularly about 1¼-inch per yard—is sufficient to account for the seams not yet having been proved to be denuded.

We have not attempted, at this stage, to follow the course of the detrital deposits in the line of the banks of the river Wear in its course towards the Magnesian-limestone escarpment and Sunderland, as we shall afterwards have to make some special observations on this part of the subject; but the sinking at Harraton Colliery, and boring near Fatfield House, give respectively 124 and 72 feet of clay and sand; thus indicating the extension so far eastwards of a great body of diluvial matter in that direction.

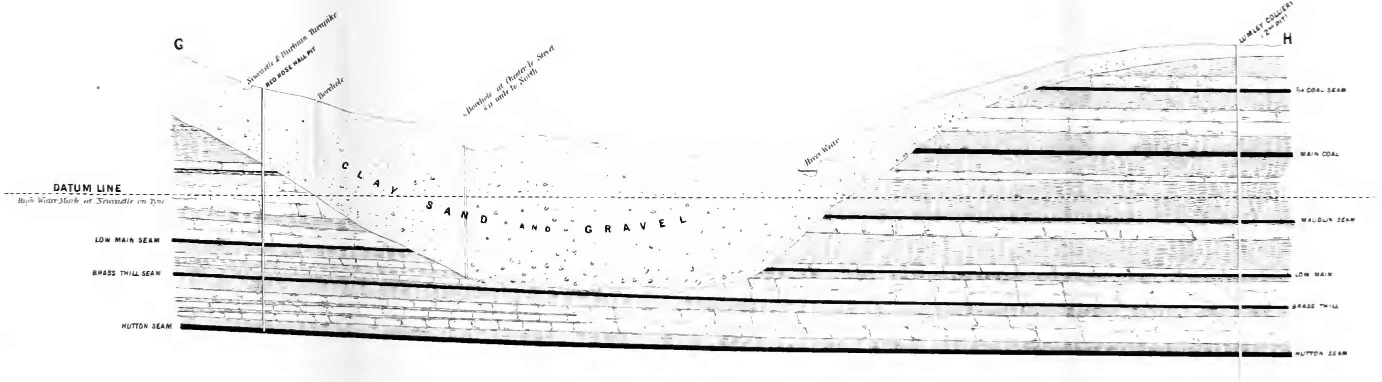
Cross Section, Plate XII., No. 5.—The Lumley 2nd Pit gives five workable seams of coal within a total depth of 54 fathoms, or 322 feet, or 166 feet below the datum line. The depth of Wash shown by a well sunk at Chester-le-Street, denudes four of these, leaving only the Brass-thill and Hutton-seam, the workings of which latter have been prosecuted through the river and beneath the Wash. The recent sinking of the Red-Rose Hall Pit again shows the existence of three seams at their proper depths; and it likewise shows a great decrease in the quantity of sand and clay, being only in extent 12½ fathoms, or 75 feet.

The curved and meandering course of the river Wear at the "Crooks," opposite the village of Lumley, shows how few obstacles presented themselves on the surface of the newly-arranged detritus and mud to decide its eventual course towards the sea.

Towards the west side of what is supposed to be the course of the "Wash," a borehole in the plantation at the junction of the Waldridge Lane with the Newcastle Turnpike, shows a thickness of 58 feet of sand and clay; and a boring for water in the village of Plawsworth gives a thickness of

Nº 5.

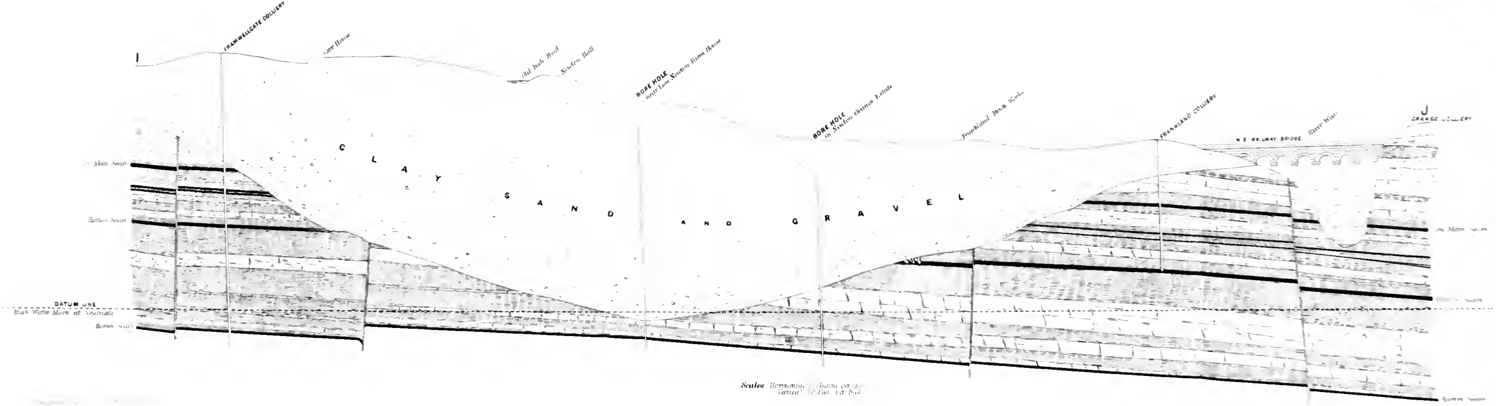
CROSS SECTION FROM RED ROSE HALL PIT TO LUMLEY COLLIERY 2nd PIT.



Scales

No. 6.

CROSS SECTION FROM FRAMWELLGATE COLLIERY TO GRANGE COLLIERY.



89 feet of sand and clay. The line of brown tint on the surface plan Plate VIII., No. 1, shows here, and also throughout the area so tinted, the thickness of unstratified matter up to the range of 40 feet.

Accurate explorations in the Hutton seam from this point southwards, show a long stretch of that seam denuded from "the Crooks," opposite the village of Lumley, extending to a little beyond the city of Durham, and this is proved by the line of discontinued workings shown in the colliery plans (kindly supplied by Mr. Crawford, junr.) of Lumley, Harbour House, Cocken, Finchale, Brasside, and Franklands; these are on the East side of the Wash. The West side of this denudation of the Hutton seam cannot be so accurately defined; its outline being as yet confined to the explorings of Framwellgate Colliery, where the Hutton seam is denuded in the line marked on the surface plan at a depth of 37 fathoms or 222 feet, the further depth (42 fathoms) to the Busty seam, which is also here being explored, is beyond the reach of the denuding influence.

The rise dyke (shown on the Map No. 1) crossing the line of Wash at "Pity-Me," in extent varying from 4 to 12 fathoms, exposes a much wider area of the Hutton seam to be denuded by the Wash.

From the higher character of the ground near and around Newton Hall, we have here the thickest section of deposited matter throughout the area under consideration; being proved, by a borehole about 500 yards to north of it, to the extent of 233 feet or 279 feet on the summit of the hill, although the bottom of the Wash at this point has gradullay risen to within about nine feet of the datum line of high-water at Newcastle.

Attention may here be called to the peculiar divergence of the present course of the river Wear, from that of the ancient course of the Wash, viz., instead of a direct passage from Frankland Farm-house, nearly north to Newton Hall, and from thence to the western extremity of Cocken property, near Cocken Ford, it seeks its present direction by Pelaw Wood through the hard rocks of Frankland and Rainton west parks, till it again returns to the ancient line at Cocken Ford.

Plate XIII., No. 6, *Cross Section.*—From Framwellgate Colliery to the Grange Colliery, gives a fair view of the following circumstances, viz. :—

The Hutton seam, at Grange Colliery, at a depth of 43 fathoms.

The channel of the river Wear at 80 feet above the datum sea level at the Frankland Railway Bridge, being cut by the present river, through solid freestone and shales, and taking off the Low-main coal seam.

The Frankland Pit exploring the Hutton seam at a depth of 28 fathoms towards the west, until it encounters the Wash along the whole western face of its workings.

The great thickness of diluvial matter deposited, proved by the borehole at Newton Grange to be about 233 feet, although at its base only nine feet below the datum sea level, and the wide extent of the Hutton seam denuded, showing a space of nearly a mile in width, once occupied by that seam, but now destroyed by the Wash, as is shown by this section.

The fine face of freestone in the quarry near Crook Hall, as well as the plan of workings in the Hutton seam at a depth of 21 fathoms, and of the Low-main seam at seven or eight fathoms within the property of F. D. Johnson, Esq., and near to the river, prove that that district is clear of the denuding effect of the Wash. But the discontinuance of operations at the little pit situated 700 yards to the north-east from the above, and sunk through 16½ fathoms of clay and sand, with but 2½ fathoms of regular strata overlying the Hutton seam, show that the working of the Hutton seam was not at this point worth prosecuting, by reason of a large portion of the seam having been denuded, and the remaining being altered and deteriorated in quality.

Kepier Pit, on the opposite side of the river, shows 19 fathoms, or 144 feet of clay and sand, and a borehole a little north-west of it (250 yards), was discontinued in clay at 180 feet from surface. The west workings of the Hutton seam displayed thick "clay backs" before being finally discontinued in the line denuded by the Wash, as shown on the plan, and the still shorter advance of the west workings of the Low Main seam (14 fathoms nearer the surface) prove the widening to the westward of the denuded course.

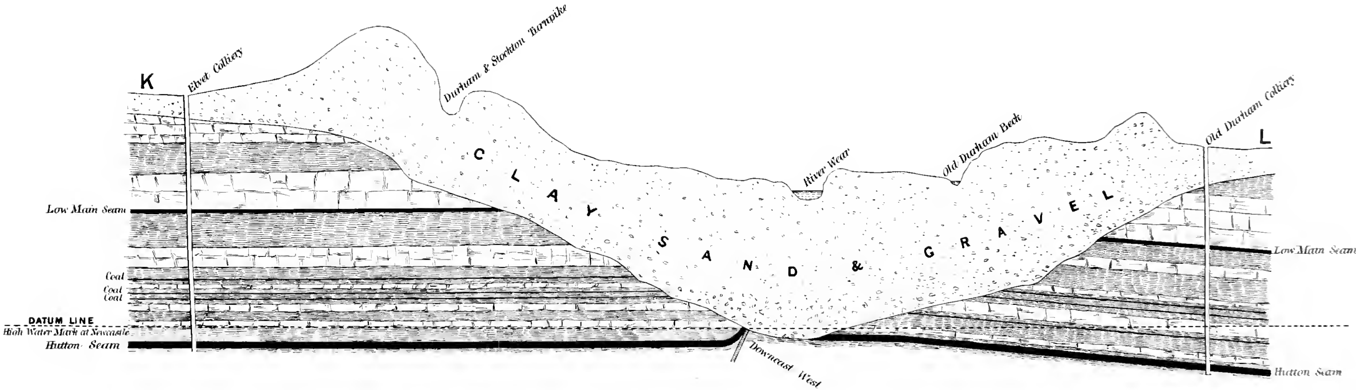
It would be difficult to attempt to account for the peculiar passage of the river through the city of Durham, cutting its winding course through the solid rock instead of a straight course along the line of the Wash.

We next trace the pretty regular continuance of the line of Wash from Gilesgate, past Maiden Castle Wood, and in a course midway between Houghall and Shincliffe; and the cutting of a channel, by the river, through solid strata, around the Cathedral and Castle must be instanced as but another to be added to the many cases of such divergence in the settling down of the waters to their present curious direction.

In cross section, Plate XIV., No. 7, the Hutton seam workings in Elvet Colliery are shown as meeting with the base of the Wash, and

N° 7.

CROSS SECTION FROM ELVET COLLIERY TO OLD DURHAM COLLIERY



Scales, Horizontal 8 Chains per Inch.
Vertical 80 Feet per Inch

denuded at a point not far distant from Shincliffe Bridge, giving a total depth of Wash of 120 feet, and its lowest surface nearly corresponding with the high-water mark "datum line," and 140 feet above the bottom of the Wash at No. 3 section.

At a short distance to the south of the line of section No. 7, but removed to the east of it, a bore-hole on the flat surface, near Shincliffe Bridge, gives a depth of 13 fathoms of clay, and shows the Low-main seam not quite denuded, being at fourteen fathoms, and the Hutton seam at twenty-seven fathoms from the surface.

The explorings, however, in the Shincliffe Colliery represent the Low Main seam as interfered with by drifted sand at its roof, about 800 yards S.W. from that shaft.

The existence westward from the rocky channel of the river, at Durham, of immense sand hills and clay banks, proved by a boring for water at Crossgate Foundry, 84 feet in thickness, with the deep railway cuttings, at Redhills, of the Bishop Auckland Branch Railway, a little to west of the Durham station, and with clay and sand of 150 and 222 feet, recently proved by borings in Bear Park and Lanchester Valley, would suggest the idea that a branch or diverging Wash or glacial current containing *debris* and silt, might have formed an accessory to the great current down the Team Valley, attempted to be described by this paper, and approaching it by the Browney river and the Lanchester valley.

The conclusion to be drawn from the remainder of our "Paper" must be more a matter of speculation, chiefly from the circumstance of the absence of borings and sinkings sufficiently near to each other, and that the underground explorings are generally in the seams underlying the Hutton seam, at a further depth of 40 fathoms and upwards; as likewise that the depth denuded, is considerably less in the directions indicated than those heretofore described.

We have not proposed other cross sections, for these reasons, but would bring our remarks on these localities to a close, at the present time, by suggesting the idea that the feeders by which the body of waters found their way into the central or main Wash, may be from this point traced in the shape of branches or tributaries in more than one direction; That one of these branches proceeded from the channel of the present river Wear, after leaving Shincliffe, by way of Butterby, Croxdale, Sunderland Bridge, Page Bank, Whitworth Park, Willington, Rough Leigh, Hunwick, Newton Cap, Escomb, Witton-le-Wear, and up the Bitch Burn to Howdon, or in the line of the River Wear from Durham to Bishop Auckland. This, with a possible further branch to the west of Bishop Auckland, and thence in the route of the tributary stream of the Gaunless by Fieldon Bridge, West Auckland, Ramshaw and Gordon, by the line of the Gordon Beck.

Another branch, and more in the line of the first described, but wider and more lacustrine in its appearance, past Bowburn, Clarence Hetton, Coxhoe, Tursdale Pit, Hett Moor, Thinford, Cornforth, Thrislington, and possibly penetrating or cutting through the Magnesian-limestone and Lower New-red-sandstone at the base or east end of the Ferry Hill ridge at Thrislington Gap, which would indicate a communication with the wide and lake-like country now occupied by the undrained plateau of Chilton and Morden Carrs, although the eventual flow from the latter may have possibly been in a southerly direction from this point towards the Tees.

We append the depths of clay, sand, and gravel, defined at the various points in the routes named, premising, however, that although some of them are to the extent of 160 feet and 120 feet in thickness from the surface, the bottom of the deepest of them is still 80 and 90 feet above the datum high water level line.

BY THE RIVER WEAR VALLEY.

	Depth of Clay, &c. Feet.
Farewell Hall borehole	159
Butterby Mill ditto	154
Page Bank sinking	90
Ditto boring	108
Whitworth Park ditto	70
Sunnybrow ditto	72
Willington ditto ... ... 66 and	82
Rough Leigh ditto ... ... 86 and	90
Newfield sinking	66
Hunwick ditto ... ... 63 and	74
Dabble Ducks, near Bishop Auckland, ditto	90
Escomb boring	110
Howden sinking	60

GAUNLESS BRANCH.

Fieldon Bridge boring	70
Brusselton Bank Foot ditto	51
St. Helen's sinking	40
West Auckland ditto	45
Ramshaw boring	60
Gordon sinking ... ... 72 and	80

BY THE FERRY HILL DISTRICT.

	Depth of Clay, &c. Feet.
Bowburn House boring	110
Bowburn Colliery sinking ... ... 108 and	120
Clarence Hetton ditto	66
Coxhoe boring and sinking ... ... 90, 77, and	78
Tursdale Pit sinking	84
Hett Moor boring	72
Cornforth ditto	50
The Carrs, ditto / Thrislington, ditto { chiefly in peat. }	80

Having thus given a detailed account so far as we have been enabled to do by the documents and information within our reach, of this remarkable and interesting Wash, or denudation, from the vicinity of Durham to the river Tyne, near Newcastle, it would appear that it has proceeded in as straight a line as the nature of the country, or what may be considered to have been the then outline of the surface would permit; and at an almost uniform inclination. We have given, in Plate IX., No. 2, a line of section drawn through the several points of the deepest parts of the denudation of the several cross sections, and this longitudinal section will show that the course of the deepest part of the denudation is as nearly uniform as possible throughout an extent of country of about 14 miles. The only irregularity shown in the longitudinal section is between the cross sections Nos. 4 and 5; but in this part we may observe that our information did not, from actual data, enable us to lay down the points of deepest denudation; and, therefore, we assume that a line drawn from No. 4 cross section to No. 5 cross section, as shown by the line A B, would represent the line of deepest depression, presenting a most extraordinary uniform declination. The inclination of the line of deepest denudation from the Houghall Pit has acquired a depth of 140 feet in the 14 miles from near Durham to the Tyne, or 10 feet per mile, equal to 1 in 528. This line of inclination would, of course, represent the deepest part of the current; the section No. 2, however, shows a deposit of sand near the city of Durham of about 300 feet above the level of high water, of the No. 3 section, in which the thickness of the deposit is only 140 feet.

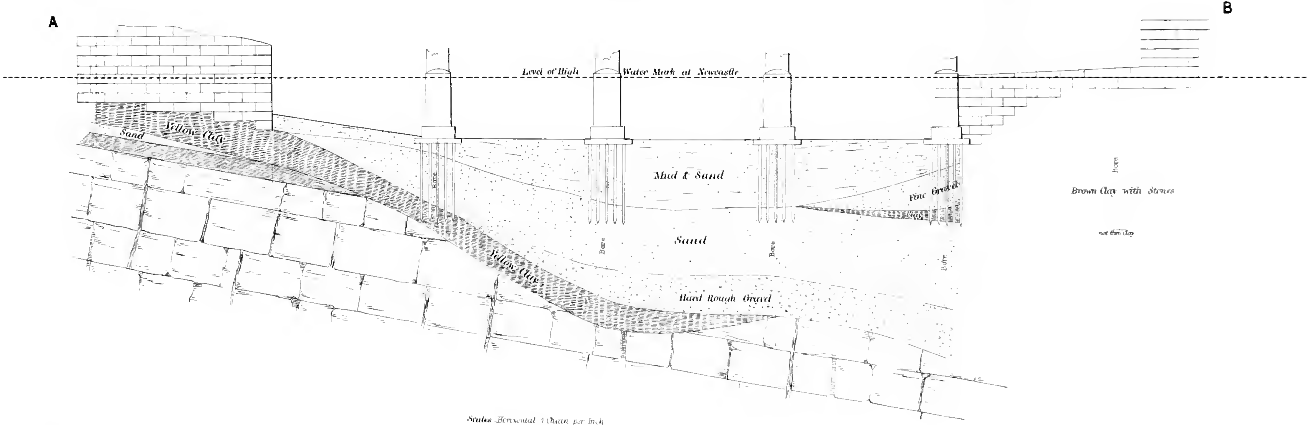
We do not pretend to offer an opinion whether this denudation has been the result of running water or of glacial action; though the uniformity in the base of the denudation and its moderate rate of inclination would incline to the latter opinion; still we must not lose sight of this fact, that a body of water which would cover the top of the deep deposit of sand of 300 feet at Durham must have had some effect in the production of a current of considerable force down the course of the Wash.

There is one peculiar circumstance relative to this Wash which requires particular notice, viz., its connection with the existing rivers and drainage of the present face of the country. In section No. 7 the deepest part of the Wash is about 100 feet below the river Wear which forms the present drainage of an extensive tract of country, and which has its exit into the sea at Sunderland. In section No. 6 it is about 90 feet below the bed of the river Wear, and in No. 5 it is about 100 feet. Thus, for several miles, the ancient Wash and the modern river each proceed at about the same inclination, the one 100 feet below the other; but in that distance they cross each other, or rather the present river crosses the line of the ancient one frequently; and what is more remarkable, although the course of the present river for a considerable distance is within the limits of the ancient deposit, as seen in section No. 7, and is again within its limits in section No. 5; yet in its course between the two localities it does not follow the direct line of the ancient river, but hollows out for itself a passage through the solid rock as at the Railway Viaduct at Frankland of more than 100 feet deep, as shown in section No. 6. And the Plan No. 1 will also show the meanderings out of the direct line which the present river takes in some places through the solid rock, in preference to keeping the direct line of the ancient river. Again, it will be seen by the map of the country that the course of the ancient river (if we may so call it) does not appear to have been altogether in the present course of the drainage of the county. Along the course of the river Wear from Durham it is generally so down to Chester-le-Street; North of Chester-le-Street, for a considerable distance the drainage of the surface is southwards until we reach the Team rivulet, the drainage is then towards the North by means of a small river, and which, in section No. 4, is shown about 175 feet above the bottom of the ancient river.

Reverting to the case of the river Wear, we find that at Chester-le-Street, that river branches off to the eastward at Chester Bridge, a little above which it crosses the ancient bed of the denudation. At Chester Bridge the bed of the present river is hard rock, and is upwards of 93 feet above the bottom of the ancient river, yet the present river has not chosen to follow the course of the ancient denudation, which would have appeared to present a uniform descending line in a northerly direction to the Tyne, but has preferred to excavate for itself a passage through the solid rock towards the east; and we may further remark that in its course towards

No. 8.

SECTION ACROSS THE RIVER TYNE, AT HIGH LEVEL BRIDGE, NEWCASTLE.



Scales Horizontal 1 Chain per Inch
Vertical 20 Feet per Inch

the sea, the river Wear passes through some rather extensive excavations of rock, and terminates at the sea with a little more than a few feet of depth at low water, above the hard rock.

It is of considerable importance, in an enquiry of this kind, to trace the outlet of such a body of water, or of ice, as the case may be, to its exit into the sea; we preferred, however, commencing at the cross section No. 3, at Norwood, at the embouchure of the Wash into the valley of the Tyne, and completing the investigation from thence to the city of Durham. The current down the valley of the Team would no doubt be met by a similar current down the valley of the Tyne; and the borings and sinkings up that valley show a great thickness of alluvial deposit below the bed of the river, and we have proofs also of similar extensive deposits of gravel and sand up the bed of the river Derwent; and we may assume also that the united currents of the valleys of the Tyne, Derwent, and Team proceeded together towards the sea through the narrow gorge formed by the precipitous banks of the river between Newcastle and Gateshead.

We give in Plate XV., section No. 8, the borings made at the High Level Bridge at Newcastle, which show the nature of the Wash or denudation at that place. It will be seen that for a considerable distance across, and indeed almost up to the present northern bank of the river, the solid rock is found at a higher level than the bottom of the Wash at cross section No. 3, at Norwood; the bottom of the Wash, however, then dips to the north, and a boring for the abutments of the north side of the bridge, was left off in clay, and did not reach the gravel which is usually deposited below the clay. It seems, therefore, likely that the point of the greatest thickness or greatest depth of alluvial matter or of the denudation, must exist at the north end of the Bridge and at the north bank of the pass, as shown in the cross section. The outline of the bank on the northern side of the river also favours this supposition, being very precipitous both in the town itself and for some distance down the river.

At about a mile below Newcastle, the river takes a sudden bend to the right, and we find at this bend, and in the direct line of the course of the river, a wash occurs in the Colliery of St. Lawrence of considerable magnitude, which has no doubt taken place by the impingement of the current proceeding from the flow of water through the narrow gorge at Newcastle. This wash formed the subject of a paper, in 1834, by Mr. Matthias Dunn, in the 2nd volume of the Transactions of the Natural History Society of Newcastle-on-Tyne, and is thus described:—

"In prosecuting the Gateshead Park Colliery, in the High-main coal, about the year 1790, the roof of the workings suddenly altered from a firm and united sandstone to a mixture of gravel. And in the year 1831, the St. Lawrence Colliery, on the north side of the river Tyne, was reöpened, and in pursuing the old workings, at the depth of about 28 fathoms from the surface, it was discovered that they had also been originally stopped by the same gravel and sandbed." Mr. Dunn also mentions, that in the neighbourhood of the Barras Bridge, Newcastle, "a similar gravel formation exists to a very considerable extent;" and also, that "I have ascertained that gravel beds have been met with in the working of Jesmond Colliery."

It would lengthen this paper to a considerable extent, to trace what may reasonably be expected to have been the discharge of the waters of this Wash into the sea, by the course of the river Tyne or otherwise. This would, no doubt, have been very desirable; but though we had, from the sinkings and borings on the banks at each side of the river, considerable information, we did not think that at the present moment we had sufficient to justify us in embodying it in our present communication, considering that it would more properly, perhaps, be made the subject of a paper on the Wash, or deposit of the valley of the Tyne, as a distinct communication, and which would, of course, comprise the river both above and below the bridge at Newcastle, and which, we trust, will follow this at no distant period.

The result of this communication may be shortly summed up by saying, that it would appear, that at some period or other, a current of water, or the occurrence of the glacial action of ice, passed down the valley of the Team, from Durham to the Tyne, near Newcastle; that such current or wash or glacial action denuded the solid strata and coal beds for a depth of from 150 to 200 feet; and that at its debouchure into the valley of the Tyne, near Newcastle, it excavated or denuded the solid strata to the depth of at least 140 feet below the present high water level at that point, and consequently very considerably below the present level of the sea. That such denudation or Wash has been subsequently filled up by the detritus partly produced by the Wash, and partly by detritus from distant localities, and that the present drainage of the country passes over, in some parts of its course, such detritus at a level of from 100 to 140 feet above the bed forming the base of such Wash or river.

We might speculate on the relative level of the sea at the present period, and that which existed when such a current denuded the strata down the Team Valley to such a depth below the present level of the sea, or the comparative level of the valley itself at the two periods; but we forbear to do so at the present time, in the hope that the facts, as regards these denudations in the coal strata, will be further investigated, and that such investigations may throw additional light upon the subject.

We know that, assuming the coal beds to have been originally level deposits, that at present they rise gradually from the sea westwards, and that the lower beds of the series of Carboniferous strata (of which the coal beds constitute the upper portion) form hills of considerable elevation to the west; it may, therefore, be that some relative change of level may have taken place since the occurrence of the deeper Wash and that of the present drainage of the country. Be that as it may, we cannot conclude this paper without expressing a hope that the subject will be further investigated by the members of the Institute (who have so many opportunities of doing so), with a view of contributing all the information possible towards the illustration of so very interesting an inquiry.

ON THE

PROBABLE EXTENSION OF THE COAL-FIELD

UNDER

THE NEW-RED-SANDSTONE OF CUMBERLAND.

By MATTHIAS DUNN.

Having read a paper on this subject to the members of the Mining Institute of the North of England, in July, 1860,* and seeing that the subject has not been noticed by any of the papers read before this Association, I have determined, on the spur of the moment, to submit a few remarks upon it, especially referring to some important facts which have recently been exhibited at the collieries of Ellenborough, Aspatria, and Crossby.

The bearing of the former paper was to show that the New-red-sandstone was traceable from St. Bees through the collieries on the whole line of coast, and up to the vicinity of the village of Aspatria, where some new sinkings have recently been made, by the representatives of the late Captain Harris, in the New-red-sandstone; and short driftings have led directly into the main coal-field, towards Bolton, and the neighbouring Mountain-limestone. (See map, Vol. VIII., page 144.)

At the Ellenborough Colliery the explorations have reached to the town of Maryport, in the Ten-quarter seam, at a depth of 100 fathoms, and have there been suspended at troubled coal, attended with very great thickening of the band, with downcast troubles in the line of the margin of the Red-sandstone.

Very much the same circumstances have attended the working of the

* For detailed Illustrations and Extracts relative to the New-red-sandstone of the above-named district, see Transactions of Mining Institute, Vol. VIII., pp. 142-160.

Crossby Colliery, at a depth of 70 fathoms; a set of dykes and bad coal, about the same course as the margin of the Red-sandstone, terminating the profitable working of the Ten-quarter seam.

To the northward of the above line of explorations, and down to the Solway, no operations in search of coal have been carried on, but sundry quarries have been worked, showing the Red-sandstone to be lying in regular strata, with a westerly dip, similar to the Coal-measures.

From the above facts I have been led to form the idea that this Red-sandstone is but the superior strata of the coal-field, and that the neighbouring coal seams will be *found underneath;* and judging from the flatness of the country around Silloth Harbour, I have assumed that the bottom of the basin will exist in that quarter, for appearances of a coal outcrop are said to exist in the neighbourhood of the Criffle mountains, in Kirkcudbrightshire.

In pursuance of this theory, I assume that the coal-field of Canonbie, in Dumfriesshire, is similarly situated, for the Red-sandstone there crops out contiguous to the pits, and the nature of the various seams of coal assimilate closely to those of Cumberland. Another corresponding fact attends the colliery of Kirkhouse, south of Brampton, belonging to the Earl of Carlisle, although a portion of it also contains coals belonging to the Mountain-limestone formation.

I have compared the sandstone in the neighbourhood of Maryport with that upon Sir James Graham's property at Netherby, and find that they are identical—that is, the upper portion; the lower part of the beds being of a much paler colour, and approximating towards specimens of the ordinary Coal-sandstone.

The deepest perforation which has yet been made in the New-red-sandstone, was by Mr. Cockburn, paper-maker, near Wetherall, who bored into it in search of water, but failed in obtaining a supply. In a letter written in August, 1862, he said—"The hole is standing 600 feet from the surface, 50 feet of clay, and 550 feet of Red-rock." This experiment shows that the rock is remarkably free from water, and that the sinkings would in all probability be free from many of those expensive operations incurred elsewhere.

But the most convincing argument as to my theory has been furnished by the Aspatria Colliery, belonging to the representatives of the late Capt. Harris, showing that a sinking took place in the Red-sandstone with a drifting into the main coal-field. The belief of the managers is that their coal was thrown down and passed underneath the said Sandstone.

All around this village and down to the Solway nothing but Red-rock is exhibited at the surface.

Since I first promulgated these opinions, I have found that many persons in the district have come to the same conclusion, although certain geological objections have been started. However, I have resolved to state the foregoing facts to be canvassed and determined by an Association of gentlemen so well able to dispose of a subject, which is supposed to comprise one of the greatest fields of coal yet untouched, and which in future generations may uphold England's greatness, and which may not have been considered in Sir W. Armstrong's able elucidation as to the duration of our northern coal-fields.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, SATURDAY, FEBRUARY 6, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD Esq., President of the Institute, in the Chair.

The Secretary read the minutes of the Council, and also the following letter:—

[TRANSLATION.]

Mons, January 15th, 1864.

Sir,—In reply to your esteemed favour of the 17th December last, I have the honour to inform you that we have forwarded to your address a complete collection of the Transactions of our Association.

In each month you will receive regularly the particulars of our monthly meetings, which will indicate to you the course of our enquiries.

If your Society publishes a complete account of your meetings, it will gratify us to receive them at the periods of their publication; more especially those relating to questions which involve practical mechanics, having their chief interest in what has been actually accomplished. We hope that our two Associations may derive great advantage from this reciprocity, and from the interchange of publications, more especially if, with this interchange of Transactions, they arrange with each other as to a mutual discussion of certain questions of a general nature, in which both are interested, relative to mining science, apart from those circumstances which are peculiar to different localities.

Should our mode of viewing any point be different from that of your members, we have no hesitation in proposing to your Society an enquiry, in common, into al that may relate to ventilation; for notwithstanding the progress which that branch of mining science has made in past time, it is incontestible that it is still much to be desired that nothing shall be omitted that may be favourable to its development, through the combined research of the two Associations of Newcastle and Mons.

Should this proposal be acceptable, we shall adopt measures in accordance with what we have said, to give effect to such coöperation.

Hoping, Sir, that your associates will find in our remarks on this subject, the expression of a desire to aid the progress of mining industry, rather than anything of an intrusive or hasty nature, we beg you to accept the assurance of our entire consideration. (Signed) GUIBAL, PRESIDENT.

To Mr. T. Doubleday, Secretary of the North of England Institute of Mining Engineers, &c.

The PRESIDENT said, he had also received a letter from M. Grateau, of Paris, who compiles the "Universal Review of Mines and Metallurgy," proposing an exchange of publications. He was not acquainted with the gentleman, but he thought it would be a useful interchange. The gentleman did not ask for the past Transactions, but only to commence the exchange from the first of January last. He would read the letter :—

[TRANSLATION.]

Paris, December 21st, 1863.

MR. PRESIDENT,—I have the honour to propose an exchange, commencing from the 1st January, 1864, of the Proceedings of the Northern Institute of Mining Engineers with the "Universal Review of Mines and Metallurgy" (*Revue Universelle des Mines et de la Metallurgie*), published at Paris and at Liège (Belgium), by M. De Cuyper.

Most of the periodical publications relating to the working of mines and to metallurgy have been so exchanged for many years. If you also would agree to do so, you can send me direct the works of the Northern Institute, and I will regularly forward you the "Universal Review," of which I am the compiler. The "Universal Review" comes out every two months, in numbers of about 200 pages, large 8vo, boards.

Waiting your answer, and in the hope of establishing relations of a scientific nature with the skilful engineers of the North of England, I have the honour, Mr. President, to offer you the assurance, &c., &c.

(Signed) É. GRATEAU, Mining Engineer,
173, Boulevard, Mont Parnasse, Paris.

The President proposed that they make the exchange.

The proposal was agreed to.

The following new members were elected :—Mr. George Scott, Albion Mines, Pictou, Nova Scotia; Mr. Alfred Hodgett's, Oak Bank Terrace, Whitehaven; and Mr. Robt. Russell, Gosforth. Mr. James Heslop, West Rainton, Fence Houses, was elected a graduate.

DISCUSSION ON THE ROCK-SALT AT MIDDLESBROUGH.

The PRESIDENT said, the discovery of Rock-salt at Middlesbrough was a most important one. Independent of the value of the salt, its discovery in such a position proved a very important geological fact, which they might presume set at rest the termination of the coal-field in that direction. He supposed when they found Rock-salt at a depth of 1200 feet in the Red-sandstone, and looking at the thickness of the intervening strata, between the Red-sandstone and the Coal-measures, they might take it for granted there was no coal at a workable depth to the south of that locality. They had frequently discussed the question as to the extension of the coal-field into Cleveland; but he thought this discovery would put an end to that discussion.

Mr. Atkinson begged to say that it was perfectly possible that coal existed under the Rock-salt.

The President—It might; but this put an end to the question as far as the depth of 1200 feet was concerned, and he would say there were other facts which proved that, in all probability, it does not extend so far south. The southernmost part of the coal-field in that direction, so far as we know at present, is rising to the bottom of the Magnesian-limestone, and it would have to be thrown down to a depth of upwards of 1200 feet, and subjected to a change of direction of the inclination of the beds if it extended beyond this locality. His opinion, as a Mining Engineer, was, that this fact, added to the fact of the coal beds rising up into the Magnesian-limestone, clearly proved the termination of the Coal-measures to the south.

Mr. Hall said, in the discussion on his paper, read at the Birmingham Meeting of the Institute, it was thought that there was little coal workable to profit beyond Hartlepool.

The President described the state in which the Rock-salt had been discovered.

Mr. Dunn said, it was not the Upper-red-sandstone, it was Trias.

Mr. G. B. Forster—That is the Upper-red-sandstone. There were only the Old and the New-red-sandstone, and this was the New.

The President supposed it was the same Red-sandstone as that which contained the salt beds and brine springs of Cheshire. It stretched across the country continuously, almost if not entirely so from Middlesbrough to Cheshire.

Mr. Hall said, it was at Hartlepool as well as Middlesbrough.

Mr. Howse mentioned that borings had been made near Croft, through sandstone and gypsum beds, and in one or two other localities on the banks of the Tees, but no indication of salt was discovered in these borings.

The PRESIDENT said, there was a boring carried down 140 fathoms; but no salt or coal was found. It did not go low enough even for the salt.

Mr. G. B. FORSTER said, there was a locality near Pierse Bridge, in which the Red-sandstone was found abutting on the Millstone Grit.

The PRESIDENT—The Millstone Grit occurs underneath the Magnesian-limestone at Knaresbrough, near Harrogate, without any intervening Coal-measures, and this was in every way consistent with the view they had always taken of the Coal-formation, namely, that they were cut off to the south by rising up to the Magnesian-limestone, or that the Magnesian-limestone was deposited over the top of the Coal-measures, and covered them. There was nothing in this boring inconsistent with that supposition. The other beds south of our coal-field were shown in Mr. Marley's section. It showed the Coal-measures approaching Hartlepool; then a district covered by the superficial deposits of the Tees, which was not clearly defined. Now it seemed clear from this boring that the strata of the lower part of the valley of the Tees was formed of this Red-sandstone.

Mr. DAGLISH said, it was a favourite idea with many of the leading geologists, that the coal-fields were once continuous. It would be well if they could get good facts to oppose such a view.

The PRESIDENT said, this was sometimes a fancy of his own; but if they had been continuous they had certainly in some places been washed away entirely; for no doubt existed that to the south of the county of Durham, the Magnesian-limestone covered the Millstone Grit, without any intervening coal beds. In a paper "On the Geology of Northumberland," he assumed that the Northumberland coal beds extended into Scotland, and that the Scotch seams and the Northumberland beds were identical. No doubt the coal in Wales was in the same position in the series as ours. It lay in the upper beds of the Carboniferous series; but how far the two coal-fields were continuous and contemporaneous, or that they were formed in different basins, and at different periods, he could not exactly say. This was a somewhat doubtful question. He did not know whether the true coal could not be formed in separate and detached basins, as well as in continuous beds. He was rather inclined to suppose that they were the result of partial deposits of basins rather than continuous formations. In the county of Durham, we had the Magnesian-limestone covering the coal, and we have 200 fathoms and upwards of coal beds, near the sea, covered by at least 30 fathoms of limestone. Go further South, and we have the Magnesian-limestone reposing, as I have said, on the strata, at the bottom of all the coal. In fact, you have no coal—you see the

Millstone Grit lying immediately under the same Magnesian-limestone. So that it is quite clear if the Coal-measures even did extend continuously southward, they had been denuded previous to the deposition of the Magnesian beds. They had never proved coal to the southward of the neighbourhood of West Auckland, through the intervening country to the south of Harrogate; but it might be that further to the south, and below the Magnesian-limestone, coal might be found, but he would not like to undertake borings at his own expense, through the intervening country to Harrogate, in the expectation of finding coal under the Magnesian-limestone. But it was supposed by some geologists that the Durham coal extended into Yorkshire. There was the same base of Carboniferous rocks and Millstone Grit occurring throughout all the intervening district that we have below the Coal-measures of Durham; but we do not know yet that the coal is continuous. He would be glad if the members of this Association would employ themselves in the investigation of the district between here and Yorkshire, and, if possible, trace the connection between the two coal-fields. He did not know much about the rock-salt in Cheshire. Here it seemed to be very thick; but it existed in the same Red-sandstone, and he did not know that it was not quite so thick in some parts of Cheshire.

Mr. Howse—The general section at Middlesbrough is much the same as in Cheshire; but in the latter locality the rock-salt occurs in two beds, whose aggregate thickness is not quite so much as at Middlesbrough.

The President said, Sir Wm. Armstrong gave us only 200 years of coal. He (the President) took the liberty to say that he thought there was more than that. This Institute, standing so prominently before the public, in a mining point of view, should, he thought, fortify themselves with as much knowledge as they could on the subject. The British Association had appointed a committee, who, no doubt, would be seeking for information. It would be well if some of the younger members of the Institute would prepare themselves especially on the extent of the Durham and Northumberland Coal-fields. The subject would come before the next meeting of the British Association, and a challenge had, as it were, been thrown out to them, as well as to other parties connected with other coal-fields of the country, with reference to the duration of such an important mineral. A most important element in the question was the coal under the sea, along the shores of Northumberland and Durham. They were approaching the sea in two or three places, in very important districts, and this would probably enable them to throw some light on the subject, even before the next meeting of the Association. So far as they knew, the coal was dipping towards the sea, throughout a great portion of the coast of Northumberland and Durham. and, he believed, the coal drifts at Ryhope Colliery were only about a hundred yards from the edge of it. The coal was dipping still eastwards, but not so much as it did. Whether there was likely to be any change in the inclination of the beds, whether it became flat within a short distance, and that the seams were continued, either level or dipping, or that the inclination of the beds took another direction, were important facts to ascertain, and were points which, he hoped, would be cleared up in short time. At Seaham, also, where they were approaching the sea, the coal was still dipping towards the sea, and he believed that so far as the explorations had gone, still further south it was also dipping. Monkwearmouth had also left off, dipping towards the sea; but at Harton and Hilda Collieries, on the contrary, the seams were rising to the sea, and at a much higher level than at Monkwearmouth. All these facts were very important to investigate; because all the unexplored coal lay beyond low water mark. He believed that as yet no coal had been worked immediately underneath the sea. At Hartley Colliery they had worked very near, but not underneath the sea.

Mr. G. B. Forster said, there had been a little working under the sea at Hartley.

Mr. Howse said, there was one important fact connected with this enquiry, and that was, that the former elevations of land were much higher than at present, and this made it extremely probable that the strata towards the east had been subjected to denudation to a great depth. Although the bed of the German Ocean was shallow in the centre and probably filled in with boulder clay, yet it might be that all the solid strata had been destroyed. The Wash section proved that the land was now much depressed below its former level. There might be a very deep sea channel which had cut away all the strata between the East coast and the Continent. This opinion was rather borne out by the President's and Mr. Boyd's paper on the Wash.

The President said, he would not go so far as that; but the result of the Wash, when they came to discuss it, would throw some light on the subject. The fact was, that the Wash had removed the strata to a depth of 150 feet below the present high water mark. They might assume that this water forming the Wash ran out to the sea. The sea then must have been at a lower level than it is now, or the land had been at a higher.

Mr. Howse—Then one must expect deep denudation of all those strata projected towards the sea.

The President—You are aware that the water is very shallow across the German Ocean.

Mr. Howse—On the Dogger Bank it is very shallow, and you get the remains of the Boulder clay there. On the eastern side you have a flat country with sand and gravel, extending several hundred miles.

Mr. Hall said, no one could dispute that there were many hundred acres of coal under the sea; but at the same time, on all this coast, and throughout Wales and Cumberland, there was now only one district where they were working under the sea, and that was at Whitehaven. The South Wales sea-district was drowned out, and the Workington sea-district was also drowned out. The occurrence of numerous slip dykes at Whitehaven had rendered the working dangerous, and it was a matter for consideration, in cases where slip dykes occurred, whether they should extend the works beneath the sea, and thus expose them to the danger of being drowned out.

The President said, Mr. Hall would think him a bold man who should recommend the taking off pillars under sea; and he was afraid he (the President) must class himself with persons of that class, for he had sanctioned the taking off pillars at Whitehaven, under the sea.

Mr. Hall said, the President would remember that the sea broke in at Workington, near Whitehaven, 40 years ago, and this colliery, like that in Wales, remained drowned out, and was not likely to be resumed.

Mr. Dunn, reverting to the subject of the paper, said, if the Red-sandstone was to be taken as the strata next to coal, he would like to know why coal should not exist under the Red-sandstone at Middlesbrough.

The President said, there was no reason why it should not, except that in working the coal in that direction, he believed the coal beds run up into the Magnesian-limestone many miles north of Middlesbrough. They had diagrams in the possession of the Institute, showing the coal terminating at the Magnesian-limestone at Wingate Grange Colliery. That was one reason why he thought the coal runs out, and would not be found at Middlesbrough. Assuming that the Coal-field forms a basin, and that the line from Hartlepool westward is one of the edges of the basin, the fact of the coal beds cropping out towards the south would rather show that this is the termination of the coal basin, and that the Magnesian-limestone, Red-sandstone, and other measures repose on the edges of it.

Mr. Dunn—The Red-sandstone might be thrown down again, and the coal along with it, if it lies on the coal.

The President said, Mr. Marley wished to correct a mistake respecting the rope used in the boring at Middlesbrough. It was stated to be flat *wire* rope, and he said it ought to be flat *hempen* rope.

This terminated the proceedings.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, MARCH 3, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

The minutes of the Council having been read, the following gentlemen were elected members:—Mr. William Routledge, Shincliffe Colliery; Mr. Nelson Boyd, 24, Upper Eaton Street, London; Mr. T. M. Wilson, Forest Hall, Benton; Mr. Chas. Steel, Ellenborough Colliery, Maryport, Cumberland. Mr. Wm. L. Armstrong, Cowpen Colliery, was elected a graduate.

A letter was read from Mr. Green, apologising for his absence, and sending specimens of the American Anthracite coal and subjacent strata.

The President said, they were extremely obliged to Mr. Green for the specimens, which were very valuable, as illustrating a description of coal with which the members of the Institute were not well acquainted. It would have given them further satisfaction if Mr. Green could have been present. It was of great importance that members should be present when their papers came on for discussion. When they were not present they could not, of course, go on with the discussion, and gentlemen who might have come from a considerable distance to take part in the discussion would be much disappointed. He the more regretted Mr. Green's absence as he had a letter from Mr. Greenwell, with some observations upon the paper, which no one could answer but Mr. Green. The following is Mr. Greenwell's letter:—

OBSERVATIONS ON "NOTES OF THE ANTHRACITE COAL REGION IN NORTH AMERICA."—Page 26.

Having recently had my attention directed to the question of Oolitic coals, I have consulted such authorities as have lain within my reach, and certain conclusions, at which I have been led to arrive, induce me to suggest to the writer of the above excellent paper, the possibility of his having committed a geological error in his diagnosis of the Lackawanna Coal-field.

From the mass of information contained in Mr. R. C. Taylor's statistics of coal, I discover that it is undisputed that the coal-field of Eastern Virginia belongs to the oolitic period; and from an observation of the "run" of country and shape of coal basins, as shown in the map, opposite to page 144, and from the sections of the detached coal-fields, pages 95 and 104, analogous to the section presented in this paper, I am induced to hazard the opinion, that the whole of the coal basins, lying between the North or Blue-mountain-ridge and the Alleghanies, are Oolitic, and that the whole of the strata (Devonian included), shown on Mr. Green's section, below the Stigmaria-shale (which probably belongs to the Oolite) are Trias.

(Page 45.)—The New-red-sandstone at Bristol is *unconformable* to the Coal-measures; where undisturbed, it lies, geologically speaking, horizontally, over all the subjacent strata, the Carboniferous and the Devonian inclusive.

NOTE.—The writer of the above remarks takes this opportunity of proposing to correct what seems to him an error becoming accepted as fact. He refers to what is called "the Lower-new-red-sandstone." There has long been observed a series of red shales and sandstones, lying under the sands of what may, strictly speaking, be called the Lower-new-red-sandstone, or, to prevent misunderstanding, the "sand" under the Magnesian limestone. These shales and sandstones are red-tinged; but they are (what the Permian is not) conformable to the coal strata, and, in the opinion of the writer, they are ordinary coal strata, altered in colour by the influence of their more recent associates. The peculiar character of the influence exercised by the Red-sandstone upon adjacent strata is worthy of investigation, and the writer's opportunities of examination, if productive of any results worth bringing before the members of the Institute, will be placed at their disposal.

Mr. ATKINSON said, he quite agreed with the postscript of Mr. Greenwell's letter, and he believed Mr. Daglish and Mr. G. Baker Forster had brought or were bringing out a paper upholding the same opinion. He meant the note correcting what he thought was an error. He (Mr. Atkinson) believed that the red shales and sandstones often found immediately beneath the sand, lying at the bottom of the Magnesian-limestone, were no part of the Lower-new-red-sandstone, but were part of the Coal-measures, inasmuch as they were conformable thereto. In some places, they had more Coal-measures under the sand, at the bottom of the limestone, than they had in other places. They had almost the whole series in one place, and a considerable denudation in another, and yet in each case they had these red shales next beneath the sand which lies under the limestone. Professors Lyell and Faraday classified these shales and sandstones below the sand, at the bottom of the limestone, he believed, as belonging to the Lower-new-red-sandstone. He believed they were mistaken. He thought they belonged to the Coal-measures, and were merely discoloured by being adjacent to the sand, at the bottom of the limestone; and Mr. Daglish and Mr. G. B. Forster, he thought, expressed the same opinion in their paper.

The President said, this quite accorded with his opinion. It could hardly be called an opinion, it was a matter of fact. They saw it almost in every case where the coal strata were covered by the Magnesian-limestone, and especially when the whole series of the coal strata existed. He mentioned this, because the Magnesian-limestone overlies the Coal-measures unconformably, from those places where the entire series of the coal beds exist, until they gradually disappear; and ultimately the Magnesian-limestone rests upon the Millstone-grit. The Red-sandstone beds do not, however, exist regularly throughout the whole extent; but wherever they do occur, they lie immediately underneath the limestone and sand.

Mr. Atkinson said, it was red shales Mr. Greenwell alluded to, as well as red sandstones; and he had noticed in sinking through the Magnesian-limestone, after you got through the sand, the first few beds of shale you enter are often red. This he believed was the case at Haswell, where they were classified by Professors Lyell and Farraday, as belonging to the New-red-sandstone series; so also he believed in the neighbourhood of Coxhoe, Thornley, and Wingate, &c. The Coal-measures were first reached at different depths and at different parts of the series, but no matter at what depth after you have got through the sand, you meet with shales and sandstones which are red in colour.

The President said, more in detail, there were borings and sinkings all the way from Wearmouth to Castle Eden and Coxhoe, and from thence to the Black Boy Colliery at the western extremity of the coal-field; throughout the whole distance the Magnesian-limestone covers the Coal-measures. It would be very well to ascertain the fact throughout the whole of that extent.

Mr. Atkinson—I think Mr. Daglish's paper will establish it.

The President—However, there was clearly a marked distinction between the sand, and the Coal-measures and the Red-sandstones of the Coal-measures; the former being quite unconformable with the two latter, which are strictly conformable to each other, but in some districts of the country there was what is called the Lower-red-sandstone and the Upper-red-sandstone.

Mr. Dunn—The Magnesian-limestone lies between the two.

The President said, his impression was, that the Red-sandstones of which he now spoke were both unconformable to the Coal-measures. It appeared that the sand, which really was only a sand when subjected to the action of water, was, when *in sitû* and dry, a loosely integrated stone, which in some parts of the country where geologists distinguish between the Lower and Upper-red-sandstones, becomes solid, and then it becomes a Red-sandstone bed, resting on the Coal-measures unconformably. This might be geologically classified as a separate bed, and might be distinguished as the Lower-red-sandstone; and in that case you have the Permian red beds above and the Magnesian-limestone between them. But the lower of these Red-sandstones would be distinct from the Red-sandstones of the upper part of the Coal-measures.

Mr. Atkinson—Infiltration of the red matter, or iron, might discolour the beds of the Coal-measures lying immediately underneath the sand. He believed that for a few fathoms after they passed through the sand at the bottom of the limestone they met with those red shales and sandstones, whatever portion of the Coal-measures was present. That was the opinion Mr. Greenwell expressed, and which he believed to be a correct one.

The President—If he recollected the result of the sinkings and borings rightly, they (the beds of Red-sandstone) lie a little below the Magnesian-limestone in the Coal-measures, and are strictly conformable to the beds of the Coal-measures, with this peculiarity, that they existed at an almost uniform distance below the Limestone, whether the whole of the series of the Coal-measures existed or were in part denuded. Thus, at Monkwearmouth, where the thickness of the Coal-measures was about 233 fathoms above the Hutton-seam, the Red-sandstone beds existed near the top of this series of beds, and are only at twelve or fourteen feet below the Magnesian-limestone. At Thornley Colliery, where only 112 fathoms of Coal-measures existed above the Hutton-seam, the Red-sandstone beds are about the same distance below the limestone beds; and so throughout the whole extent of the coal-field and without reference to the thickness of the Coal-measures, the red shales and sandstone beds were found only at a short distance below the limestone beds and what may be supposed to have been the denuded surface of the Coal-measures.

Mr. Dunn said, he knew a case in point where the Magnesian-limestone was between the Upper and Lower Red-sandstone.

The President—Is the Lower-red-sandstone unconformable to the Coal-measures?

Mr. Dunn said he could not speak to that. This was at Curthwaite, a little distance from Carlisle. It was the same Magnesian-limestone traceable all the way to Whitehaven.

The President—I think your section shows it is unconformable. He would beg to observe that this discussion had been somewhat extended, and not being immediately connected with the subject before the meeting, he would suggest that it be postponed until they had Messrs. Daglish and Forster's paper before them. He would afterwards add, as an appendix to the discussion, some copies of Borings and Sinkings, showing the position and thickness of the Red-sandstone and shale beds at some of the important collieries, and they would go on with the discussion on Mr. Green's paper. The specimens shown by Mr. Green, he thought, certainly tended to the opinion that the coal was not in the Oolitic formation. These specimens would seem rather to belong to the lower coals.

Mr. Atkinson—It looks like the Coal-measures proper.

The President—Lower in fact than the ordinary coal strata of England. He thought the hardness of the specimens showed that the formation had been deposited in the vicinity of the older rocks. Mr. Greenwell said, that Mr. R. C. Taylor's statistics of coal led him to the opinion that this coal was in the Oolitic formation, but they had produced on him (the President) the contrary impression. The members would be able to refer to that work which they had in the library. His impression was that that coal was in the real anthracite part of the Coal-measures. But they must postpone the discussion of the paper until the next meeting, when he hoped Mr. Green would be present.

MINERS' RELIEF FUND IN BELGIUM.

The President continued—The next question for discussion was the Miners' Relief Fund in Belgium; and here again they were unfortunate in the absence of Mr. Morison. That gentleman had sent a letter stating that he was suffering from a severe attack of cold. He asked them to postpone the discussion, as he hoped to have some more recent information of the working of this fund, to lay before the members. This paper showed the low rate of wages paid in Belgium: two shillings per day on the average. The principle of the fund was a very good one, but they would know that the coal there belonged to the Government.

Mr Berkley—Does he give any idea of the value of money in Belgium? Two shillings per day there may be as good as five shillings here.

The President said, that considering the class of people there, two shillings per day and the cheap living of the country, they undoubtedly had labour much cheaper than in England. Like all funds of this description, it would be prosperous at the beginning, until they came to the time when they ceased to get new, and had to support the old members; when the funds, unless the payments were such as to meet this state of things, would naturally be exhausted. However, this fund has been 20 years in existence, and appears, as yet, in a flourishing state.

PARADOXES IN VENTILATION.

Mr. Atkinson said, he had nothing to add to his former remarks.

Mr Dunn referred to the case at Springwell Colliery. In the chimney there was a great deal of steam and smoke. This came from the underground engine The question was—what difficulty was there in making this a regular air-course. He was not speaking of gas in the goaves.

Mr. Atkinson said, it might be done with proper care; but Mr. Heckels in his paper pointed out the liability to accident from such connection. Suppose they had a furnace at Springwell, where the engine is at present, and it was necessary to put it and the boiler fires of that engine entirely out, Mr Heckels showed that by heating the other shaft you might draw the hot air from one to the other, and so cause a fire in the intermediate workings. If you have two furnaces at two separate shafts, and if you slack one and drive the other hard, there was a possibility of accident. He (Mr. Atkinson), thought however, with an ordinary amount of care, and a proper arrangement, two upcasts might be connected with the same system of ventilation without any great risk. At the same time, if circumstances would admit of it, it would be better to avoid having two upcasts so connected.

The President—Certainly it would be safer to have only one current, but there were circumstances which might require two.

Mr. Berkley said, in the peculiar position of the two upcast shafts at Springwell, as they were previous to Mr. Heckels' visit, an accident might take place from any variation in the strength of one of the furnaces. The present upcast, U, caused by the heat from the underground boilers, would be reversed if a connection was made in the returns between the upcasts U and X, as I have proved.

Mr. Atkinson said, it was perfectly possible to alter the arrangements so as to lessen this liability. Mr. Heckels, on page 54, says—"I need hardly observe, that with the openings in the joints of the No. 1 upcast shaft walling, however small, communicating with the return air-courses in the upper seam, leading to No. 2 upcast, that a current composed of a portion of the general ascending current in No. 1 upcast, would be formed immediately on the temperature of the upper part of No. 1 upcast shaft becoming reduced to below that of No. 2 upcast shaft, whether by water proceeding from the tubbing, and by a partial slackening of the furnace below, or by any other cause." This was not strictly correct, and it might be far from correct, under certain conditions. A great deal depended on the amount of the difference of temperature between the two upcast shafts, and other conditions, as to whether the one would or would not draw from the other. It depended, for instance, a great deal on the lengths and areas of the air-ways extending from one upcast to the other, and on the quantity of air passing along them, as to how much difference of temperature would be required. A very slight difference in any case might not do it. If there was a long distance between the one and the other, and a strong current, it would not take place till there was a very great difference of temperature. This could only occur under extraordinary circumstances, and (as when a segment of tubbing bursts) they could use extraordinary means to meet such circumstances.

The President said, they must not allow this subject to pass over without coming to some conclusion upon it, and try and put it into a tangible shape. He hoped at the next meeting they would have the Wash paper on for discussion. It would come out this month.

The meeting then broke up.

APPENDIX.

Account of the strata sunk through the Magnesian-limestone, Sand, and beds of Red-sandstone, at the undermentioned collieries along the Eastern and Southern margin of the Durham coal-field :—

Monkwearmouth Colliery.

		Fms.	Ft.	In.	Fms.	Ft.	In.
Unconformable.	Clay and gravel...	19	3	0			
	Limestone	33	1	7			
					52	4	7
Beds stratified conformably.	Sand, sandstone, and shale	2	2	10			
	Red metal stone...	1	3	0			
	Shale, sandstone, and coal	1	2	2			
	Blue and red metal	3	0	0			
	Red and grey freestone	3	3	0			
	Strata (Coal-measures)...	221	2	5			
					233	1	5
	Hutton-seam				286	0	0

Ryhope Colliery.

		Fms.	Ft.	In.	Fms.	Ft.	In.
Unconformable.	Clay and gravel...	3	1	0			
	Limestone	34	3	6			
	Sand	16	0	6			
					54	2	0
Beds stratified conformably.	Blue metal	0	5	6			
	Red metal	0	1	10			
	Strata (Coal-measures)...	216	0	8			
					217	2	0
	Hutton-seam				271	4	0

Seaham and Seaton Collieries.

		Fms.	Ft.	In.	Fms.	Ft.	In.
Unconformable.	Clay and gravel...	9	0	0			
	Limestone	58	3	6			
	Sand	0	3	0			
					68	0	6
Beds stratified conformably ...	Sandstone and shale	1	5	4			
	Red metal	1	1	6			
	Strata (Coal-measures)...	179	0	4			
					182	1	2
	Hutton-seam				250	0	8

Shotton Colliery.

		Fms.	Ft.	In.	Fms.	Ft.	In.
Unconformable.	Clay and gravel	13	1	11			
	Limestone	52	5	5			
	Sand	4	0	3			
					70	1	7
Beds stratified conformably.	Sandstone and shale	1	3	4			
	Red metal	0	2	6			
	Shale	0	6	1			
	Red metal	2	0	9			
	Strata (Coal-measures)	105	2	1			
					109	4	2
	Hutton-seam				179	5	9

THORNLEY COLLIERY.

		Fm.	Ft.	In.	Fm.	Ft.	In.
Unconformable.	Clay and gravel	3	0	0			
	Limestone	22	4	6			
	Sand	6	0	0			
					31	4	6
Beds stratified comformably.	Sandstone and shale	2	0	4			
	Red scared metal	2	0	0			
	Shale and coal	0	4	8			
	Red and blue metal	0	1	6			
	Grey metal	0	3	0			
	Red metal	0	5	6			
	Strata (Coal-measures)	106	2	2			
					112	5	2
	Hutton-seam				144	3	8

MURTON COLLIERY.

		Fm.	Ft.	In.	Fm.	Ft.	In.
Unconformable.	Clay and gravel	5	3	0			
	Limestone	69	3	1			
	Sand	4	5	8			
					79	5	9
Beds stratified conformably.	Blue metal	0	3	0			
	Red and black metal	0	4	6			
	Shale and coal	0	1	0			
	Soft red metal	0	3	6			
	Red posty metal	2	2	6			
	Strata (Coal-measures)	160	4	1			
					165	0	7
	Hutton-seam				245	0	4

ON

THE MANUFACTURE OF IRON

IN CONNECTION WITH THE

NORTHUMBERLAND AND DURHAM COAL-FIELD.

By I. LOWTHIAN BELL.

THERE is probably no district where the manufacture of iron is carried on which presents more features of interest, and embraces within its range greater variety, than that which is worked in connection with the coal-field of Northumberland and Durham. Notwithstanding this, the iron metallurgy of the North, which it will be the province of this paper to explain, owes none of its importance to the existence of any of the ores of iron being found in those measures which belong more immediately to its coal formation. In Scotland, Staffordshire, and South Wales, the shales of the Coal-measures contain bands and nodules of ironstone in sufficient quantity to supply immense works, established in these localities, for smelting iron. The coal-field of the North of England, on the contrary, extensive and productive in mineral fuel as are its strata, is singularly deficient in those ores of iron which distinguish many other carboniferous districts. An explanation, then, of the prominent position occupied, as a seat of the iron trade, by the locality under consideration, must be looked for in another direction, and a very brief mental survey of the geology of the adjoining country will furnish the necessary information. Starting from the coal-field itself, which, as containing the fuel required for smelting, may be considered as the keystone to the whole, we arrive within no great distance at strata which abundantly compensate for that poverty in ironstone already spoken of as inherent to our Coal-measures themselves.

The district known as the Newcastle and Durham coal-field contains an area of something like 700 square miles, and in shape may be roughly considered as an isosceles triangle, having its apex coincident with the coast line at Warkworth. As the sea principally forms its eastern barrier, our observations are necessarily almost exclusively confined to those formations bounding it on the west and south. In the former direction, *i.e.* towards the west, a narrow strip, having a width of four or five miles, of the Millstone Grit, rising up from under the coal formation, separates this latter from an extensive tract of country, of which the Mountain-limestone is the prevailing rock. From the south-west corner of our coal-field, and separated from it by a great expansion of the Millstone Grit, accompanied by Mountain-limestone, we pass over a thin wedge of the Old-red-sandstone and enter upon the new red, to the west of which the Carboniferous-limestone again appears as a long, narrow, and curve-shaped district, extending from Penrith to Whitehaven, and of importance in describing our subject. On the south, and skirting the coal-field on the south-east, we have the Magnesian-limestone some half-dozen miles in width. Beyond it, forming for some distance the valley of the Tees, is the New-red-sandstone, separating, by an interval of twenty miles, our collieries from those hills of Lias in Yorkshire, the ore of which will occupy the greater portion of the subject of this paper.

We will now briefly allude to the position of the minerals which constituted the sources whence our furnaces in former times were supplied, adding a few remarks on their practical application ; and then consider those means which at the present day furnish our greatly-extended iron works with that immense quantity of raw materials which their increased capacity demands.

We may pass over, without further notice at the present moment, both the immense beds of coal, of the purest kind, in this northern coal-field, and the inexhaustible supplies of lime furnished by the extensive tracts of Mountain and Magnesian-limestone previously alluded to. We shall, therefore, at once proceed to name the different combinations in which ironstone is found in the various strata of the measures already referred to, reserving any further remarks when we come to speak of the composition and nature of the minerals generally.

IRONSTONE OF THE COAL MEASURES.

Many of the numerous beds of shale associated with the coal formation in this neighbourhood contain, interspersed in their thickness, nodules of ironstone, but these have rarely been sufficiently abundant to lead to their being worked for smelting purposes.

Above the seam of coal known on the Wear as the High Main, and separated from it by a distance of eighteen inches, is a continuous band of this ore. It is four and a half inches thick, and was formerly wrought on Waldridge Fell for the Whitehill Iron Works, and subsequently at Urpeth and its vicinity, for the furnaces at Birtley. Another thinner band, only two inches in thickness, formed the roof of the Huttom seam, near Birtley. From the fact that both these were extracted by simply bringing down the roof of the old coal workings, it was expected to supply the furnaces there at a very cheap rate, and this might have been so had the quantity per acre been larger. As it was, the ironmasters had to seek far and wide for supplies, and, in consequence, the cost of stone was ruinously high. The present partners in the Birtley Works have kindly placed in the writer's hands their cost-book, and from it, after the furnaces had been in operation four or five years, the following results are taken :—

	Ironstone used per Ton. Cwts.	Qrs.	Lbs.	Cost on Ton of Iron. £	s.	d.
1835	65	0	19	2	18	1½
1836	67	1	5	1	17	6½
1837	71	0	27	2	7	3¼
1838	67	0	17	2	2	8¾

From their furnace books this appears to have represented the calcined weight, and hence the yield of the raw stone must have been from 25 per cent., gradually falling to 22. At this time hot blast was in use at the Birtley Works, the system having been introduced there about 1831. Mr. George Clayton Atkinson, a partner of the Tyne Iron Company, has obligingly given the following as their consumption for the year 1812, using stone of a similar kind to that described above; indeed, a considerable quantity was purchased from the owners of the Birtley Iron Works, previous to the erection of the establishment at that place. The quantity used was 8772 tons, which cost on an average 16s. 1d. per ton. During that year they produced 2547 tons 18 cwts. of iron, and, in addition to the above-mentioned ironstone, there were consumed 284 tons of hematite. If the small quantity of this latter ore is assumed to give 50 per cent., the yield of the clay ironstone would be something above 27 per cent. The difference in the produce may have arisen from less perfect freedom from adhering shale in the Birtley furnace workings—a supposition corroborated by the increased consumption there to the ton of iron in later years, when failing supplies would prevent proper "weathering" of the ironstone. In 1812, the ironstone per ton of iron cost the Tyne Iron Company £2 18s. 10d.

Near Wylam, according to Mr. Benjamin Thompson, who erected the works at that place, a mine was opened in 1836, out of which, from a section of 4 feet, four bands, measuring together 10½ inches, were obtained. This cost, it was stated, 7s. 6d. per ton of 22½ cwts., and yielded 30 per cent. of iron. Another working supplied nodules, having a per centage of 35 to 37, and costing 11s. 6d. per ton. The united produce, however, of both did not suffice to supply 150 tons weekly, and these mines were speedily abandoned when a less precarious mode of obtaining ironstone offered itself, although the cost of the latter would, at the period of its first introduction, have not been less than £2 on the ton of iron.

At Shotley Bridge, on the western edge of our coal-field, and consequently low down in the series, is a deposit of ironstone, which has been far more extensively worked than any other seams found in our Coal-measures. According to a description by the late Mr. William Cargill, in a working having a section of about 7 feet in height, 12 to 15 inches of stone were obtained from six or seven bands. The ironstone from it cost 7s. to 8s. per ton. At a depth of 4½ fathoms below it, and lying above 20 inches of coal, is a bed of shale about 3 feet thick, containing 6 to 7 inches of ironstone. The total yield of both seams, contained in an acre of ground, Mr. Cargill estimated at 5324 tons. In later years, however, according to a detailed report communicated by Mr. Edward T. Boyd, the average produce of the first-mentioned seam, "The Ten Band," as it was called, at that time was 8 inches of ironstone in a working 5 feet 9 inches high, and in the other bed his section gives—

	Ft.	In.	Ft.	In.
Good coal	1	6		
Splint ditto	0	7		
			2	1
Ironstone	0	4½		
Shale	3	6		
			3	10½
			5	11½

For a limited supply, the quantity of ironstone found in this neighbourhood might have sufficed; but an immense work having been erected upon it, comprising 14 blast furnaces, serious inroads were soon made on its resources. From information formerly received, it would not appear, whatever might be the richness of clean stone, that its yield, as delivered to the furnaces, exceeded 26 per cent. The cost on a ton of iron, for ironstone, at Shotley was 25s. to 30s., which compelled the owners of this establishment to look to another district for their supplies, so that at the present time every pit on their royalties is laid in.

A small quantity of ironstone continues to be extracted from a landsale colliery at Hedley, which is smelted at Wylam, and, as the writer believes, some is still worked by the Weardale Iron Company near Tow Law. In a general sense, however, it may be assumed that ironstone of the coal formation of the North of England forms no element, at the present day, in the consumption of the blast furnaces of that district.

THE IRON ORES OF THE MOUNTAIN LIMESTONE.

Following the order of our description of the geology of the country, the deposits of ironstone connected with the mountain limestone next demand notice. In this series there occurs a bed of shale 30 feet in thickness, in the whole of which considerable quantities of nodules of ironstone are interspersed. The late Mr. Thomas J. Taylor, in evidence on the Border Counties Railway Bill before a Parliamentary Committee, in 1854, stated this shale bed to contain 9680 tons of ironstone to the acre, of which he assumed practically 6000 could be obtained. Its cost he stated to be 6s. 6d. to 7s. per ton, and its yield such as would require $3\frac{1}{4}$ tons of stone to produce one ton of iron, equal to 30·5 per cent. Mr. Benjamin Thompson, who worked this bed at Hareshaw, informs the writer that 8470 tons of ironstone per acre was its contents, and of this the lowest 6 feet contained two-sevenths of the whole. Allowing one-third for loss, he considered 5647 tons as the practical produce of an acre. Its yield he gives as 33 per cent., and its cost 9s. per ton of $22\frac{1}{2}$ cwts., equal to 8s. per ton of 20 cwts. At Redesdale, from data possessed by the writer, the cost of ironstone for a ton of iron was 29s. 3d. This deposit has been somewhat extensively wrought at Hareshaw and Redesdale, as well as attempted at other places. In all these localities, however, the workings have been discontinued.

At Chesterwood, about two miles from Haydon Bridge, there was opened out, some years ago, a seam of what in some measure resembled the famous "black band ironstone" of Scotland, containing, however, much more coal than the celebrated ore of this name. It varied, according to Mr Bigland, who worked it, from three to four feet in thickness. The raw stone contained 20 to 25 per cent of iron; but instead of two tons of raw mineral producing one ton of calcined, as in the case of Scotland, three tons were required at Chesterwood; so that the richness of the calcined stone was about the same, viz., 60 per cent.

Mr. Bigland states that for several years they obtained 20,000 to 25,000 tons of the raw stone, until the bed was exhausted in that locality in 1855, after less than ten years' working. The deposit has been traced to other places, but in each case it is thin and poor in metal.

In Alston Moor many of the mineral veins traversing the mountain limestone contain a considerable quantity of a hydrated peroxide of iron, as well as amorphous carbonate of iron. A bed of the latter, lying on the surface, but of very limited extent, was worked by the writer's firm at Nenthead, and smelted at Wylam. The iron produced from it, as well as from other carbonates and oxides from the same district, was of excellent quality; but unfortunately the supplies were too uncertain and too costly. The ore in the veins themselves at one time was tolerably pure carbonate, yielding perhaps 30 per cent. or more of iron; but it gradually passed into carbonate of lime, from which it was with difficulty distinguished. At the present day, only a small quantity is worked at Alston. On the other hand, at Weardale the veins contain so much carbonate and oxide of iron that furnaces have been erected at Tow Law, by Messrs. Attwood and Baring, for their reduction.

The small district of mountain limestone spoken of as stretching from Penrith to Whitehaven, contains very large quantities of most valuable red hematite, containing 60 per cent. and upwards of iron. It is sold at Whitehaven at about 10s. per ton. Its position is uncertain, in a mining point of view, occurring in detatched masses of varied thickness. This locality, as well as that near Ulverstone, of a similar character, is of importance in connection with the northern coal-field, inasmuch as considerable quantities of the hematite ore are brought over to the east coast as a mixture with our own ironstone; while, to the furnaces smelting the produce of the Whitehaven mineral field, coke from our side is conveyed.

IRON ORES OF THE LIAS FORMATION.

The lias rocks of Yorkshire constitute by far the most important source from which the needful supplies for our furnaces are derived. The seams of ironstone belonging to this formation crop out on a considerable extent of the coast line of the shale beds, which, in addition contain large balls of the same ore. In rocks so liable to disintegration from atmospheric influence, these have fallen away, and, in consequence, considerable quantities of ironstone, freed from the adhering shale, are to be found on the beach as rounded pebbles, and even as masses of rock. In modern times, the ore so separated from its parent bed attracted the attention of those ironmasters who had commenced smelting the ironstone of the coal-field. Mr. Joseph Cookson, in a very interesting document drawn up for the writer, mentions that, for the Whitehill furnace, built in 1745, and abandoned before the end of last century, ironstone was gathered in Robin Hood's Bay, and conveyed by water to Picktree, on the Wear, near Chester-le-Street, and carted from that place to the works. Soon after the year 1800, the Tyne Iron Company obtained ironstone in a similar way from the beach between Scarborough and Saltburn; and, according to Bewick, in his work on the Cleveland Ironstone, that firm commenced, between the years 1815 and 1820, to tear up the stone from its bed at different parts of the coast. The exposed character of the Yorkshire shores, and want of shelter, rendered the conveyance of ironstone to the Newcastle furnaces a task of great difficulty and of some danger; and it was, therefore, not until the stratum furnishing it was discovered inland, on a line of railway at that time recently opened, that any large quantity of this lias ironstone was consigned to the ironmasters of the Tyne. It is stated that the discovery of this bed is due to a Mr. Wilson, then a partner in the Tyne Iron Company's Works, who pointed out its position at Grosmont, about five miles from Whitby, in 1836. The seam being 4½ feet thick, was cheaply worked, sent down the railway, and shipped at all seasons for the Tyne, where it would, at that time, cost about 9s. per ton. It is probable that, ultimately, as much as 80,000 to 100,000 tons of it were annually smelted in the north country furnaces.

Much surprise has been expressed at the time which elapsed between this discovery in 1836, and the period when the importance of the bed of ironstone became so immensely increased by the large quantity of ore extracted from mines opened in it since 1850. This is not so difficult of explanation as might at first appear. The Whitby ironstone, as it was then generally called, was known over a distance of coast not far short of ten miles, and its character to the west, five miles inland, had been also sufficiently explored. Over the whole of this area its yield of metal had been uniform, viz., about 25 per cent. No doubt the owners of the blast furnaces, which had been built on the Tyne for smelting local ores, were too glad to obtain a cheaper stone elsewhere, particularly when hot blast increased the consumption of their furnaces, already indifferently supplied, and competition with Scotland ran down the price of iron. Whitby harbour, for these firms, was more convenient than the Tees, because vessels coming down in ballast more easily ran into the former than up the somewhat intricate navigation of the river, and there was no reason to suppose that a seam of ironstone, which had so uniformly maintained a low per centage over fifteen miles of country, should, in this respect, as well as in others, change so rapidly in the next dozen miles. That the introduction of the stone from Whitby did not confer any great advantage on the Tyne smelters is proved by the fact that, for fourteen years after its discovery, only two furnaces, and those built under somewhat peculiar circumstances, were added to the five in blast previous to the importation of this ore. The fact was that, with the exception of one or two years, the Tyne never could compete in selling "mine" iron against the market price of the Glasgow makers. No practical man, therefore, was likely to be led into the expenditure of capital by a year or two's prosperity, with the knowledge of the superiority conferred on his Scotch competitors by their fields of black band. Between the years 1840 and 1850, the cost of ironstone on the ton of iron was never, at the Birtley Iron Company's Works, less than 26s. 3d., and this only when the trade was in an exceedingly depressed condition; 30s., and as high as 34s., was the more ordinary figure. The average selling price of iron at Glasgow, over eleven years was within 6d. of the cost at the Birtley Iron Works, and to obtain this the owners must have charged the coal from their own pits at less than 2s. per ton laid down at the furnaces. During five years of the eleven, iron was cheaper at Glasgow than the cost at Birtley, even with the coal supplied at 1s. 6d., or thereabouts, per ton. In 1845, both the owners of the Walker and of the Tyne Iron Works sought to mend their position, by looking for royalties of black band in Scotland, and, in consequence, there was brought for some time a considerable quantity of that mineral to the river Tyne.

Matters were in this state when Messrs. Bolckow and Vaughan, who, in 1840, had built a rolling mill at Middlesbrough, added, at Witton Park, in 1846, the process of smelting to their operations. They were induced to do so by an offer of ironstone to be supplied from the coal-field near Bishop Auckland. In these expectations, as had happened to their colleagues on the Tyne, they were disappointed, and like them, they had recourse to Whitby. In one respect, however, their position differed from that of the ironmasters further north. In a voyage of fifty miles, ten miles more or less is a small sacrifice compared with securing a good harbour, but where the ironstone measures were known to run close to the mouth of the river upon which the works were placed, it was obviously a matter of importance to draw the supplies of ore, or as much of it as could be obtained, from the nearest point. Examination of large detached masses which had fallen from the cliff led Messrs. Bolckow and Vaughan to Skinningrove on the coast, at which place, to their surprise, they found the bed had thickened out from 4½ feet to nearly 14½, and instead of 25 per cent. of iron, it contained 31. So far was accident; but that firm experiencing the usual inconvenience arising from an exposed place of shipment, sought for, and found in 1850, the position of the ironstone inland. It is not pretended that the merit of original discovery belongs to Messrs. Bolckow and Vaughan in reference to this extraordinary deposit of ore. On the contrary, Mr. Jackson, the father of the present owner of Normanby Hall, sent, in 1811, two wagons of it to the Tyne Iron Works. Mr. Bewick, senior, was also, a year or two before its position inland was recognised by Messrs. Bolckow and Vaughan, aware of its existence near Guisbro'. Indeed, so early as 1839, a Mr. Neasham had despatched an entire cargo to the Devon Iron Works at Alloa, in Scotland, at which establishment it met with an indifferent reception, being tipped over the rubbish-heap very soon after its arrival. In the minds of none of these gentlemen, however, did the mineral excite that confidence in its value which the subsequent labours of the Middlesbrough firm ascertained it possessed, and to whom undoubtedly is, therefore, due the merit of having introduced it to the immensely important place it now occupies. The lias rocks contain other beds of ironstone, to which reference will be hereafter made, when the composition of the Main Cleveland seam, and its use as an ore of iron are spoken of.

We have thus seen that in a district embraced within the four counties of Northumberland, Durham, Cumberland, and Yorkshire, the coal formation contains the usual clay ironstone; the mountain limestone has furnished to a limited extent some black band and nodules of ironstone, and is now affording spathose ore and brown hydrated peroxide of iron, as well as very large quantities of the finest red hematite; lastly, in the lias beds of Yorkshire there are found inexhaustible deposits of an argillaceous ore. Besides all these, and profiting by the return of light colliers, some small quantities of other ores, both foreign and British, are conveyed to the Tyne, but not to an extent to render them worthy of more especial notice. The composition of the various minerals now in use will be given when the subject of their metallurgical application comes, in its proper place, to occupy our attention.

HISTORICAL ACCOUNT OF THE MANUFACTURE OF IRON IN THE NORTH OF ENGLAND.

It is now proposed to show in what order, and in what manner, the various ores of iron, met with in the different geological measures in the North of England, have been made available in a metallurgical point of view.

Before entering on this part of his task, the writer would take the opportunity of expressing his acknowledgments to Mr. Hodgson Hinde, to whose antiquarian researches he owes some valuable information respecting the earlier production of iron in the North of England.

Notwithstanding the varied character of the different ores of the district under review, and the want of indication of metallic contents of some, the property that even these have of "rusting" on exposure to air and moisture appears to have made known the existence of all at a very early period of our history. The labours of Hodgson, Wallis, and others, leave little or no doubt that the smelting or reduction of iron ore was carried on to a considerable extent in this part of the country during its occupation by the Romans. Vast heaps of iron scoriæ may be seen on the moors in the parishes of Lanchester and Chester-le-Street, in the county of Durham, and in the valleys of the Reed and the Tyne, on the mountain limestone, in Northumberland. It is remarkable that none of these are very remote from one or other of the Roman stations which are scattered over these two counties. The same observations respecting an early use are, to some extent, applicable to the lias ironstone, and no doubt proper investigation would indicate a similar state of things wherever iron ores were near the surface, and the state of society required the metal they contained. That furnaces, or "bloomeries," were continued or re-established in some of the same situations, is proved by an inquisition of the death of Gilbert d'Umfraville, Lord of Redesdale. In the catalogue of his possessions, A.D. 1245, there are mentioned, "forgiæ quœ reddunt ferrum, quod reddit per annum iiij l ijs;" and that iron works existed in the county of Durham in the early part of the 17th century appears from a curious tract written in 1629, entitled "A Relation of some Abuses committed against the Commonwealth, composed especially for the county of Durham." The author, who signs his initials "A. L.," instances as the first abuse the great destruction of timber, chiefly for the sake of bark for the tanneries, but in one instance, at least, for smelting operations. He says, "There is one man, whose dwelling-place is within twenty miles of the city of Durham, who has brought to the ground (to omit all underwood) above 30,000 oaks in his lifetime, and (if he live long enough) it is doubted that he will leave so much timber in the whole county as will repair one of our churches if it should fall, his iron and lead works do so fast consume the same."

Hitherto, of course, all these smelting operations have reference to the small bloomery or hearth in which, with a little ore and some charcoal blown by the wind in exposed situations, or subsequently by rude bellows, a "bloom" of malleable iron was obtained.*

The German colony of ironworkers at Shotley Bridge established themselves at that place in the reign of William III. At some time or another afterwards a small high-blast furnace, five or six feet in the boshes, was erected there, the remains of which, according to information received, are still visible. Wallis, in his History of Northumberland, published in 1769, mentions an iron work which existed some years previously at Lee Hall, near Bellingham, under the management of a Mr. Wood, "who made a good deal of bar iron, but charcoal becoming scarce, he removed to Lancashire, where he attempted (unsuccessfully) to make it with pit coal." Although bar iron only is mentioned, there is no doubt, from the remains still existing, that Wood also produced pig iron. Charcoal iron was also smelted from some of the bands of clay ironstone at Bedlington, where the old calcining kilns are still visible, or were so until very recently. No iron, however, has, as far as can be ascertained, been made there for more than a 100 years.

The inroads which iron smelting, together with other metallurgical operations, &c., had made upon the forests were such that, in the reign of Queen Elizabeth four Acts of Parliament were passed to restrict the consumption of timber, especially when applied to the manufacture of iron. To supply the deficiency thus occasioned, schemes were proposed so early as 1612, by Sturtevant, and subsequently, in 1621, by Dud Dudley, for smelting iron with pit coal. The unsuitability, however, of the arrangements in use for smelting with charcoal, when applied to

* This simple mode of smelting, viz., the bloomery, is the one which appears to have been universally adopted in the first instance for obtaining iron. Captain Grant, who has recently returned from his expedition to the source of the Nile, found the inhabitants of the Land of the Moon gathering small nodules of ironstone from the sides of the hills, and smelting them on the bare ground in a charcoal fire. The blast was produced by two or four persons working each a small bellows formed of wood and goat skins. At the end of the wooden bellows-pipe was a short tube, or tuyere, of baked earthenware, which conveyed the compressed air to the fire. The bloom resulting from the operation was beaten into a thin bar and then drawn out into wire, which was chiefly used for ornamental purposes.—*Private Letter to the Writer from Captain Grant.*

mineral fuel, in all probability delayed this important amelioration taking effect for a 100 years after its first suggestion by Sturtevant. The small furnaces and bellows of very limited power, which did very well with charcoal, would be literally useless when applied to coal or to coke. After various ineffectual attempts by Buck and others, about 1713 the Darbys of Staffordshire reduced the application of pit coal to one of practical utility in that county. Darby's progress, however, must have been slow and his success limited, for the number of blast furnaces in the country had, in the meantime, decreased from 300 to 59, so that in 1740 the make of pig iron in England had fallen to 17,850 tons, from about 180,000 tons—the chief portion of our requirements being imported from Sweden and Russia. To Mr. I. Cookson, who had recently purchased the Whitehill estate, near Chester-le-Street, the merit belongs of erecting and working the first blast furnace with coked coal in the North of England. The Whitehill furnace was 35 feet high, 12 feet across the boshes, and produced 25 tons of iron per week. The blast was supplied by a bellows, worked by a water wheel placed on Chester Burn. Its mode of supply of ironstone was from the thin bands on Waldridge Fell, and from Robin Hood's Bay, as has been already mentioned. The coal, of course, was obtained from the immediate vicinity. Mr. Joseph Cookson, a descendant of the founder of pit coal smelting in this district, has given many curious particulars respecting this early attempt. The iron was used for colliery castings, and latterly for Government ordnance. Frequent interruptions, for want of water to drive their wheel, led at length to the furnace being "gobbed," and ultimately abandoned, about the close of the last century.

Whatever advantages, in point of minerals, any district might stand possessed of, its power for turning them to profitable account depended at that time on the existence of a fall of water sufficient to drive the needful blowing apparatus. The discoveries of Watt prevented the want of hydraulic power being any longer an impediment, and in a short time the obedient steam engine was appointed to supply the necessary blast to iron furnaces. Notwithstanding the poverty of our coal-field in ironstone, the high price of iron (£8 per ton) and the small quantity of ore required for a furnace, when 40 tons of iron was the usual week's make, induced the Tyne Iron Company, in 1800, to erect their two furnaces and a steam blowing engine at Lemington. An idea of the cost of manufacturing pig iron in those days is not without interest, as illustrative of the disadvantages of this coal district as an iron-field. The particulars are kindly furnished by Mr. G. Clayton Atkinson, one of the present members of that firm, so that their correctness may be relied on.

Ironstone	... 3·44 tons	at 16s. 1d.	... £2 15 5		
Hematite ore	... 0·11	„ 31s. 6d.	... 0 3 5		
					£2 18 10
Flux (chalk)	... 1·38	„ 2s. 0d.	...	...	0 2 9
Coke	... 2·40	„ 12s. 5d.	...	...	1 9 9
Labour, &c.	...	...	...	...	0 14 2
					£5 5 6

These details are of the year 1812, when cold blast alone was employed. The make from one furnace was 2547 tons; equal to 49 tons per week. The ironstone, with the exception of 806 tons of "beach stone," was all the produce of the thin bands of our coal measures.

In 1825, pig iron rose in value to the unprecedented price of £12, and as a considerable portion of the stone smelted by the Tyne Iron Company was the produce of pits at Urpeth and its neighbourhood, Messrs. Perkins, Hunt, and Thompson, who were extensively engaged in coal mining in that locality, blew in two furnaces in 1830, which they had built at Birtley. Their operations, like those of their predecessors at Lemington, exhibit, with equal force, the absence of the elements of success in our coal-field for the manufacture of iron, even when the fuel was supplied to the furnaces at the low rate of 2s. per ton or less. The following is copied from their cost-book, and represents the workings for two furnaces for 1835, when hot air was used—an improvement introduced at Birtley in 1831. The make was 4390 tons, or only 42 tons for each furnace per week. The cost per ton of iron was, for—

Ironstone ...	£1 18 $1\frac{1}{4}$
Flux (chalk) ...	0 2 7
Coal (five or six tons probably) ...	0 7 $0\frac{1}{2}$
Labour, &c. ...	0 14 $2\frac{1}{4}$
Sundries ...	0 14 2
	£3 16 1

In 1836, the furnace at Wylam was put into blast by Messrs. Thompson Brothers to smelt ironstone, expected to exist in great abundance there, as has been already explained.

We have now arrived at that period in our history of the iron trade which was followed by a gradual, but, ultimately, an entire change in the sources from which the furnaces of this district derived their supplies of ironstone. So early as 1836, a cargo of that ore, which in time displaced all others at the then existing works on the Tyne, so far as local ironstone was concerned, was sent from Grosmont, near Whitby, to Birtley. In the year 1833 and up to 1839, pig iron had ranged from £4 10s. to as high as £9 per ton in Wales. The demand for iron in this neighbourhood was so vastly on the increase, that the ores of the coal strata could not meet the growing requirements, and the Whitby stone had not inspired much confidence either for economy or quality of the iron it produced. In consequence, speculators began to pay attention to those deposits of ironstone spoken of as being connected with the mountain limestone. Redesdale was the place selected by Mr. Stephen Reed, Mr. Thomas Hedley, and others, where the stone existed, as has already been described, and where coal could be obtained from a seam from 2 to $2\frac{1}{2}$ feet thick, situated in the same geological formation.

Although pig iron had fallen in 1840 to £3 12s. 6d. at Glasgow, and in 1841 was selling at £3 5s. per ton, a second work, to smelt the same bed of ironstone with the coal $2\frac{1}{2}$ feet thick, lying 70 fathoms below the ironstone, was put in blast at Hareshaw; a second furnace was subsequently built at Redesdale, and two more at Hareshaw. There is no doubt that the iron produced from this bed of ironstone was of a very excellent description. Both works, however, were nearly twenty miles from a railway, and twenty more from a market, so that their iron cost, according to Mr. T. J. Taylor, 12s. per ton for carriage to the consumer. After some years of fruitless struggle to meet the competition offered by Glasgow, both of these establishments were closed and finally dismantled.

About 1840, Messrs. Bigge, Cargill, Johnson, and others, who had purchased from the projectors of the Redesdale Works that concern, had their attention directed to the beds of ironstone described as lying in the coal measures near Shotley Bridge. A pair of furnaces were speedily erected and set in blast. A larger company was formed, and an immense establishment was constructed. Twelve blast furnaces were built, large rolling mills and all the necessary mines, mining villages, &c., followed in rapid succession. Until 1850 the furnaces went on devouring the minerals found in the neighbourhood at an alarming pace, having in the meantime made extensive trials of those from the lead veins of Weardale. In 1850, the recent discoveries in Cleveland promised relief from the impending famine, and in a very short time, in spite of a distance of about fifty miles, the ironstone from that district, with some hematite for a mixture, entirely superseded the stone lying adjacent to the furnaces.

In 1842, Messrs. Losh, Wilson, and Bell, who for fifteen years had been making bar iron, built a blast furnace at Walker for producing forge pig by smelting their mill-furnace cinders with Whitby stone, and this was followed by a second one in 1844, so that these were the first furnaces ever built expressly for smelting the recently-discovered ironstone at Whitby.

About this period, Mr. Charles Attwood, in concert with Messrs. Baring and Co., of London, purchased a small furnace then recently erected at Stanhope by Mr. Cuthbert Rippon, and built five others at Tow Law for smelting the "rider ore" (carbonate and oxide) of the lead veins. There is no doubt, that owing to the extreme irregularity of this kind of material, immense labour and expense were at first incurred, and, as regards the quality of the produce, frequently with very unsatisfactory results. Better acquaintance, however, with the veins and their contents, has enabled that firm now to produce iron of a very high class—so good, indeed, as closely to resemble in composition and quality the celebrated German "Spiegel Eisen." For bar iron purposes it bears a high name, and has, like its prototype in Germany, been found well adapted for the manufacture of the finer kinds of steel, an application, as is well known, confined exclusively to the purest descriptions of metal.

In 1846, Messrs. Bolckow and Vaughan erected the furnaces at Witton Park, in the Auckland district, for smelting ironstone expected to be obtained in that vicinity. We have already heard how these hopes were disappointed, and Whitby resorted to, as it had been by almost every furnace owner in the north.

Although only remotely connected with our subject, it may as well be mentioned that a company of gentlemen had erected at Cleator Moor, near Whitehaven, a couple of blast-furnaces for smelting the hematite iron ore of that district, an example which has been somewhat extensively followed since. The iron made is of good quality, and, the ore being rich, an immense quantity, as much as 500 tons weekly, or more, is said to have been run from one furnace.

To avoid interrupting the remainder of our subject, which will hereafter be confined almost exclusively to the Cleveland stone, mention may be made of other trials to render available the bed of ironstone nodules of the mountain limestone. This was attempted at Brinkburn, on the Coquet, but after a very short trial the works were closed. Another experiment was made at Haltwhistle with a similar view, but it also was abandoned soon after the erection of the works.

At Bedlington, two furnaces were constructed to smelt the same bands, formerly used at the charcoal works in that locality, with an admixture of Yorkshire stone, mill cinder, and other materials, but these also were only a short time in operation.

We have now arrived at the period when the newly-discovered Cleveland bed of ironstone was about to supersede all other modes of supply of this mineral, and the present will therefore be a convenient opportunity of estimating the position of the iron trade previous to its introduction. This will be most readily done by glancing at a list of the furnaces then in existence, which were as follows :—

Furnaces.	Proprietors.	No.	Description of Ironstone used.
Lemington	Tyne Iron Co.	2	Whitby stone, black band, and hematite.
Birtley	Birtley Iron Co.	2	Whitby stone, &c.
Wylam	Bell Brothers	1	Do, black band, hematite, &c.
Redesdale	Redesdale Iron Co.	2	Nodules from the mountain limestone formation.
Hareshaw	Hareshaw Iron Co.	3	Do. do.
Shotley Iron Works	Derwent Iron Co.	14	Bands of ironstone from coal measures, and hematite.
Walker	Losh, Wilson, & Bell	2	Whitby stone, black band, hematite, &c.
Towlaw & Stanhope	Weardale Iron Co.	6	"Rider ore" from lead veins, and a portion from coal measures.
Bedlington	Longridge & Co.	2	Whitby ironstone, and a portion from coal measures.
Witton Park	Bolckow & Vaughan	4	Do. do.
	Total	38	Furnaces

The entire make of all the furnaces would never exceed 150,000 tons per annum during the period under consideration.

We have now (*i.e.* A.D. 1851) brought up the account to what substantially in principle is the position at present occupied by the manufacture of iron, on or in connection with the Newcastle and Durham coal-fields. In pursuing the narrative illustrating the development of the trade, it will be convenient to give, in the order they arise, some account of the character and composition, both of the raw materials used and of the products obtained.

COAL.

Notwithstanding the varieties of coal which occur in the Northern Coal-field, the whole, with few exceptions, are more bituminous in character than the produce of other localities in this country. North of the Ninety-fathom Dyke, is the district where the Low Main of the Tyne (Hutton seam of the Wear) furnishes the least caking coal we possess, but even here the small coal when coked loses all trace of its original form, and leaves the ovens as large masses of coke. At Wylam, Walbottle, and other places, a thin layer of a dry burning splint coal does occur in connection with a seam of a highly caking description, but the entire quantity of it, and of any other similar variety, is very insignificant. The caking property, although very valuable for many purposes, entirely unfits the coal of this district for use in the raw state in our blast furnaces, where its fusing property, by impeding the blast, causes the contents of the furnace to hang and slip, and thus to descend at irregular intervals. Against this disadvantage, however, possessed by our coal, may be placed the extreme hardness and strength of the coke it produces, which is thereby rendered capable of resisting the crushing effect of a high column of materials as they exist in our blast furnaces. An experiment at the Clarence Works showed that a cube of coke, two inches on a side, supported a weight of twenty-five cwts. when cold, and twenty cwts. when hot, before it was crushed. Dr. Richardson gives the following analyses of coal from this and other districts, the latter being given for the sake of comparison:—

	Locality.	S.G.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.	Per centage Coke left by Coal.
18	Samples, Newcastle	1·256	82·15	5·31	1·35	1·24	5 69	3·77	60·67
36	Do., Wales	1·315	83·78	4·79	0 98	1·43	4·15	4·91	72·62
8	Do., Scotland	1·259	78·53	5·61	1·00	1·11	9·69	4·03	54·22
7	Do., Derbyshire	1·192	79·68	4·94	1·41	1·01	10·28	2·65	59·32

The purity of the coal is by no means an infallible indication of its fitness for the manufacture of a suitable coke for iron furnaces. Not only are comparative freedom from ash and sulphur indispensable, but we must have concurrently the power, which depends on some circumstance we do not clearly understand, of producing coke sufficiently compact to come down to the region of fusion in our furnaces, without being much crushed on its way.

To form an idea of the extent to which ash and sulphur exist in the coke of the South Durham Coal-field, the following analyses are extracted from the Clarence Laboratory journal:—

Ash Per Cent.	Sulphur Per Cent.
5·86	0·58
5·79	0·68
7·54	0·77
9·00	0·44
8·33	0·50

As a rule, 6 per cent. of ash and about 0·60 of sulphur may be considered as the average analytical results of the best coke of the district just quoted. Following the example of our neighbours abroad, plans have been introduced into this neighbourhood of submitting coal of an inferior description to a washing process, by which, where the earthy matter is not part and parcel of the coal itself, a very large quantity of impurity is easily removed.

LIMESTONE.

A very few words will exhaust this section of the subject. In certain districts the Magnesian-limestone, although differing little in colour, &c., from the rock in other localities, is nearly entirely carbonate of lime, and the Mountain-limestone almost invariably, from its purity, satisfies the conditions required by the iron smelter. These two, but principally the latter, with a little chalk, brought by coasting vessels as ballast, constitute the flux in the iron furnaces. The following analyses from the Clarence Laboratory show the composition of—

	Mountain Limestone, Harmby.	Magnesian Limestone, Raisby Hill.	Chalk from South of England.
Insoluble in hydrochloric acid	2·00	0·95	1·96
Peroxide of iron and alumina	0·98	0·40	1·24
Lime	53·35	54·62	53·84
Magnesia	1·08	0·43	0·63
Carbonic acid	43·02	43·42	42·99
	100·43	99·82	100·66

The chalk contained twenty-one per cent. of water.

IRONSTONE OF THE LIAS.

It will be foreign to the intention of the present communication to attempt anything like a minute description of the district over which the deposit of ironstone, embraced within the title of this section, is found. Mr. John Marley, whose name has been, from the first, associated with its discovery in the neighbourhood of Middlesbrough, and who has devoted much attention to its geological position and extent; and the late Mr. Joseph Bewick, to whom a long practical acquaintance with the subject gave abundant opportunity of studying this question, have both written on the subject at considerable length. To their works—the former in the Transactions of the Northern Institute of Mining Engineers, and the latter in a work on the Cleveland Ironstone—those persons who desire more detailed information are referred.

It may be, however, briefly stated that Mr. Bewick gives the dimensions of the field of ironstone as thirty miles by sixteen, from which he deducts sixty miles for denudation, giving a net area of 420 square miles. The brother and partner of the writer, Mr. John Bell, who possesses a very complete knowledge of the district, prepared models and maps of the country, which agree pretty closely with these estimates. Mr. Bewick roughly considers the yield to be 20,000 tons per acre, and hence infers that close on 5,000 million tons are contained in the Main Cleveland seam, within the limits laid down.* We have already seen in the preliminary account of this bed of ironstone how varying in thickness it is. In some places, also, it becomes more or less split up by bands of shale, a circumstance which of course interferes greatly with its commercial value. Commencing with Grosmont, near Whitby, where it was first wrought in a systematic way, there are found two seams of ironstone known as the Pecten and the Avicula bands. The former consists of 3 feet of ironstone, divided in the middle by a bed of shale 1¼ feet thick. Separated from this by 30 feet or more of shale, is the other seam, the Avicula, embracing 4½ feet of ironstone, along with 2 feet of shale; and it is by these two bands uniting, as well as increasing in thickness, that we have, further north, the Main Cleveland seam, as it is termed. In the northern portion of the field considerable irregularity in character is also observable. At Codhill the bed has an extended height, but is so interspersed with foreign matter that it is found necessary to confine the mining to a section of 5½ feet; and the produce, from the circumstance of more or less shale bands running through the ironstone itself, is only about 28 per cent. of metal. A little to the east of Codhill are the Belmont Mines, where the shales thin out, and in consequence, the yield of iron is about 30 per cent., the seam at the same time having increased in height to 7¼ feet. At Skelton, still further east, a marked improvement, both in thickness and in quality, is again discernible. The workings there are frequently 10 feet high, and a recent analysis of the entire section of stone gave about 36 per cent. of iron. The north side of the vale of Guisbro' is formed by an elevated ridge of land separating this valley from that of the Tees. At the western edge of this ridge are

* In an estimate recently made by the writer, based on the researches of Messrs. Hugh and T. J. Taylor, T. Y. Hall, &c., there would appear to be in our northern coal-field six thousand million tons of coal left for future use; so that there is just about fuel enough in the one district—reserving it for that purpose exclusively—to smelt the ironstone of the main seam of the other.

the Normanby Mines, where the stone is worked at an average thickness of about 8 feet, containing 31½ per cent. of iron. There is a general dip of the seam to the east from this point, and in its progress in that direction there is a gradual increase in thickness, and a little improvement in per centage of iron. It continues in this way past Eston and Upleatham, until it reaches Rockcliffe, where it attains a thickness of nearly 18 feet, after which it splits again into bands, and as far as is known, resumes towards the east and south the character formerly observed as attaching to it at Grosmont, near Whitby.

From the details just given it will be seen that, although the quantity of ironstone in the Main Cleveland seam is practically inexhaustible, the portion which, in recent years, has yielded such immense quantities of rich mineral, as far as we can at present judge, occupies comparatively a very limited area. Commencing at Swainby, near Osmotherley, which is the most western point where the bed is worked, its thickness is not much above three feet, and the per centage of iron under 28. It improves gradually in a north-eastern direction past Kildale, where a working was attempted, and abandoned, by the writer's firm. It is not until we reach Codhill, 13 miles from Osmotherley, that the seam is considered worth extracting; and a line from this point to Rockcliffe, on the coast, a distance of twelve miles, will probably be found as forming the southern boundary of the best stone, so that after making the necessary allowance for denudation, 20 to 30 square miles may be assumed as the extent of the area, of which a considerable portion lies at a great depth.

Much more irregular in its features is the so-called Top seam. At Normanby and Eston little more than its position can be recognised, and throughout the entire field it varies from a few inches to many feet in thickness. In richness of iron it is not less changeable, giving from 20 to 35 per cent. of metal, according to the locality from which the sample may be taken. In the main seam there exists a certain degree of uniformity, even in the change of thickness and richness; but in the Top seam both alternate very frequently in a most unlooked-for manner. On the western side of the district, Ingleby Greenhow is the most northern, and indeed the only place where the Top seam has been wrought in that direction. In the mine there its thickness was 2 feet, and its richness in iron 34·75 per cent. On the other side of the valley it thinned away to a few inches, containing 37·65 per cent. of metal. Near Osmotherley the seam is several feet thick, and in it a few inches at the top contain 41 per cent. of iron; these are succeeded by 3 feet of stone, with 24·5 per cent. lying upon the top of 10 feet, giving 16·70 per cent. of iron. On the east coast, at Port Mulgrave, Messrs. Palmer formerly worked a small district of the Top seam, 4 to 4½ feet thick, which on analysis gave 30·99 per cent. of iron. In Goadland Dale, Glazedale, Frynp Dale, and Danby Dale, this seam varies from 5 feet to 8 or 9 feet in thickness, and yields from 20 to 25 per cent. of iron. In one case it is as low as 9·33, and in another case as high as 30 11 per cent., but both of these results were from a very limited area. Unless the magnetic ironstone worked at Rosedale Abbey is a portion of this Top seam, about which some doubt has been expressed, all the workings in connection with this bed have been abandoned from the causes just enumerated.

A word or two respecting the mode of extracting the ironstone from the Main Cleveland seam in the northern portion of the field, *i.e.*, near Middlesbrough, will probably not be considered as altogether superfluous. There is a portion of the bed at the top 3 feet thick, over and above the heights of the seam formerly given, and separated by a parting from the remainder of the bed, which parting varies from being a mere point of separation to a thickness of 6 or 7 inches. When it attains this latter thickness, or even less, its contents are so impregnated with bisulphide of iron as to give 28 per cent. of sulphur. This band being easily detached from the ironstone, was applied in the chemical works at Washington as a substitute for ordinary pyrites, and continued to be so used until a manufactory at Middlesbrough was able to consume all the produce of the district on the spot. An analysis of the 3 feet and of the sulphur band are to be found in the table hereafter given. The 3 feet is left in the workings to form the roof of the mine. The remainder of the seam varies from 8 to 10 feet in height, and, indeed, occasionally reaches 16 feet, or even more. In extracting the stone, headways are driven 9 feet wide and 90 feet apart, from which, at intervals of 30 feet, boards are excavated 15 feet wide. By this system "pillars" are left 90 feet long by 30 feet wide. When the limits of the royalty are reached, or when, from any other cause, it is deemed necessary to work the pillars, they are removed, with something like a loss of 10 per cent. of their contents, so that in a good working, free from faults, the whole of the ironstone, within, perhaps, 7½ per cent., can be brought away.

The following tabulated results of analyses will give a correct idea of the component parts of the Main Cleveland Ironstone seam, taken from that portion of the district where it is found in the greatest perfection :—

	Normanby, average of Seam worked.	Eston.	Upleatham.
Protoxide of iron	38 06	39 92	37·07
Peroxide of iron	2·60	3 60	4 48
Protoxide of manganese ...	0 74	0 95	0 00
Alumina	5·92	7·86	12·37
Lime	7·77	7·44	4 67
Magnesia	4·16	3 82	2·69
Potash	0 00	0·27	0·00
Carbonic acid	22·00	22 85	23 46
Silica	10 36	8 76	10 63
Sulphur	0 14	0·11	0·00
Sulphuric acid	0 00	0 00	0 00
Phosphoric acid	1·07	1·86	1 17
Organic	0 00	0 00	0·00
Water	4·45	2 97	3 36
	97 27	100 41	99 90
Metallic iron	31·42	33·62	31 97
Authorities	Clarence Lab.	Dicks. Geo. Survey.	Crowder.

	Skelton.	Skelton.	Normanby 3-feet Roof.	Sulphur Band.
Protoxide of iron	45·60	44·31	33·86	9 97
Peroxide of iron	—	—	·47	—
Protoxide of manganese ..	·75	—	·96	—
Alumina	8·51	11·66	6 92	8·47
Lime	6·31	4 66	5·82	·49
Magnesia	3·85	2·33	3 84	1·07
Potash	—	—	—	—
Carbonic acid	21·30	27·25 } includes water.	25·00	—
Silica	10·54	7·66	15·24	10·94
Sulphur	—	1·04	·40	{ 28 37* / 24 82
Sulphuric acid	—	—	—	—
Phosphoric acid	2·92	1·80	1·40	—
Organic	—	—	—	—
Water	—	—	3·69	13 20
	99·78	100·71	97·60	97·33
Metallic iron	35·46	34·43	26 66	—
Authorities	Clarence Lab.	Clarence Lab.	Clarence Lab.	Clarence Lab.

The relationship existing among the earthy constituents of the Cleve-

* Sulphur and iron, as bisulphide of iron ; 28·37 sulphur, 24·32 iron.

land ironstone, it will be seen, varies somewhat in different localities. This is not to be wondered at, for, in fact, the seam itself in the same section is by no means uniform in its composition. A moment's inspection of the furnaces working the ironstone of the district, enables a practised eye to perceive a very marked difference in the general character of the slag compared with that usually seen at iron works. Although it flows hot and fluid, it is extremely stony in its fracture, with scarcely a vestige of a vitreous nature. A very short comparison of the relationship which the earths bear to each other in ores of other parts of the country with those under examination, will explain this. The following may be instanced :—

	Low Moor.	Parkgate.	Butterly.	Brierly.	Stanton.	Cleveland.
Silica	60	44	54	60	50	34
Lime	9	13	11	9	13	27
Magnesia	8	19	9	7	17	14
Alumina	23	24	26	24	20	25
	100	100	100	100	100	100

The following analyses show the composition of slags produced at different works :—

Slag from	Wales. Cyfarthfa.	Wales. Dowlais.	Staffordshire. Dudley.	So Yorkshire. Low Moor.
Silica	45·00	43·2	38·76	43·5
Alumina	16 5	12 0	14·48	11·0
Lime	27·7	35·2	35 68	33 6
Magnesia	4·5	4 0	6·84	3·6
Protoxide of iron	3·6	4·2	1·41	8·1
Sulphur	1 4	—	·98	·8
Potash	—	—	1·11	—
	98·7	98·6	99·26	100·6
Authorities	..	Berthier.	Dr. Percy.	

Those from Cyfarthfa and Low Moor were analysed under the writer's eye. In the case of Low Moor the iron was chiefly metallic.

On comparing the composition of the slags from the Welsh, Staffordshire, and South Yorkshire works, just given, with those from the furnaces in Cleveland, the great dissimilarity in constitution will at once be perceived, and a little further examination will show, that with the composition of our ores no mere addition of lime can ever imitate the vitreous slags of those localities just mentioned.

The following analyses illustrate this :—

	Slag from Clarence.	Clarence.	Clarence previous one repeated.	Clarence.	Ormsby.
Silica	30·40	27 80	27·68	27·65	29 92
Alumina	20·72	22·28	22 28	24 69	21·70
Lime	36·88	40·45	40 12	40·00	38·72
Magnesia	4·25	7·21	7 27	3·55	6 10
Protoxide of iron ...	3·64	·61	·80	·72	·32
Ditto manganese ...	1·02	trace	·20	·35	·80
Sulphur	1 34	2 00	2 00	1·95	1 61
Potash	·50	—	—	·46	—
Soda	—	—	—	·99	—
Phosphorus	—	trace	—	·26	·07
	98 75	100 35	100 35	100·62	99 24
Authorities ..	Clarence Lab.	Clarence Lab.	Clarence Lab.	W. Crowder.	Clarence Lab.

There is one circumstance connected with the composition of these slags which may have some interest in a chemical point of view, inasmuch as it may throw some light on a subject not yet very deeply examined, namely, that of the comparative volatile nature of the earths, or of the comparative facility with which they are decomposed and vapourised. In all the analyses hitherto made by the writer, the composition of none of these slags corresponds with the amount of earthy matter introduced into the furnace; thus, in the three specimens of slag from the Clarence furnaces the silica, alumina, lime, and magnesia bear the following average ratio to each other, as expressed in whole numbers :—

Silica.		Alumina.		Lime.		Magnesia.		
30	+	24	+	41	+	5	=	100

After analysing the Normanby ironstone which was used about that time, and adding to its earthy constituents those introduced in the coke and limestone, the slag, by calculation, should have been, as regards the above-named elements, composed of—

Silica.		Alumina.		Lime.		Magnesia.		
29	+	16	+	46	+	9	=	100

The analysis in the School of Mines would, it is true, give a somewhat different result, but one which, nevertheless, does not correspond with actual examination of the slags, even had a similar quality of mineral been in use at Clarence. The Eston stone, smelted with the same kind of coke and limestone, should have given slags containing the earths in the following proportions :—

Silica.		Alumina.		Lime.		Magnesia.		
28	+	18	+	45	+	9	=	100

There escapes, as may be easily seen, from the furnaces on the Tees, &c.,

vast volumes of white vapour, which condense, or partly condense, with great facility. That there is a difference in the readiness with which it does this, may be inferred from the fact, that while large quantities of condensed matter are intercepted in the pipes for leading the gas to the boilers, a great amount travels many yards before it reaches a lofty chimney, from which it escapes as a white cloud, and this cloud goes a long distance in the atmosphere before it is finally dispersed. Nothing short of entire interception of the vapour will enable us to judge whether the discrepancy between calculation and fact can be reconciled. The writer is now engaged in arranging a steam pump which, by continued exhaustion through water or otherwise, will effect, no doubt, complete condensation of each of the component parts of this fume, when some light may be thrown upon the nature of the volatilized portions of the minerals used in our blast furnaces.

This fine dust has been examined at the Clarence Laboratory, and although the analysis proves nothing, having been taken at one place only in the connecting pipes, a statement of its composition may not be devoid of interest. It gave—

Silica and sand	34·82
Alumina	16·00
Lime	12·15
Magnesia	·57
Peroxide of iron	8·20
Oxide of zinc	4·60
Sulphuric acid	8·80
Potash	·40
Soda	6·85
Chlorine	1·56
Water	5·60
	99·55

Clarence Laboratory.

From a more recent examination of the fume, taken at different distances from its point of exit from the furnace, the varying proportion of lime would indicate that this earth maintains the condition of vapour longer than the other constituents of the condensed matter :—

At 30 yards from the point of exit the dust contained				9·0 per cent of lime.	
At 60	Do	Do.	Do.	12·5	Do.
At 130	Do.	Do.	Do.	14·0	Do.

In order to supply that deficiency in silica noticed as existing in the slags, and which might possibly affect the quality of the iron itself, there was added to the charge at the Clarence Works a silicious mud, and subsequently at Eston, freestone, by Messrs. Bolckow and Vaughan. A vitreous slag resulted, but no very marked improvement being noticed in the iron, the addition was discontinued.

TEMPERATURE OF BLAST.

The uniform practice in the whole district is to blow the furnaces with heated air. Sufficient data are not possessed to enable us to speak with any degree of certainty respecting the application of cold blast; but as far as actual experience goes, it is in favour of the idea that the lias ironstone would prove very intractable under that mode of smelting. In the year 1841, from some reason or another, cold air was used during four months at Birtley. The furnaces only ran 42 tons per week of white iron, produced by a consumption of 3½ tons of coke to the ton. At Clarence an attempt recently was made to operate on the Cleveland ore in the same way; twice the quantity of coke was used which is required when making foundry iron, and only white pig was obtained.

A more elevated temperature being wished for than is easily commanded by means of heated iron pipes, various experiments were tried at the Clarence Works, and ultimately Cowper's stoves were introduced. In these, by an alternate system of heating a mass of brickwork in closed vessels of iron, and passing the air through the same, a temperature of 1000° F. and upwards, in the blast was obtained. The condensation, however of the furnace fume, the apparatus being heated by the waste gases, so interfered with the efficiency of the apparatus that the system was modified. Previous experiments were then continued, in which an arrangement of clay pipes, iron pipes, and forge cinders was made to replace the bricks. This was a great improvement, the temperature of the air was increased up to 1200° F., and the tubular arrangement permitted the apparatus to be more easily cleaned. In time, however, the same inconvenience from the condensed fume interrupted the value of the results, and the plan was abandoned. At no time was the high temperature maintained with that regularity upon which success alone depends. Enough, however, was ascertained to give encouragement to the idea that a steady increase of 500° or 600° in the blast would have been serviceable.

To avoid the inconvenience of the flue dust, Messrs. Cochrane erected large gas generators to obtain carburretted hydrogen and carbonic oxide from the imperfect combustion of coal. The writer is unable to say what have been the advantages attending this mode of operating. The loss of heat from such a plan of applying coal and other sources of expense will probably be a serious impediment to the full measure of usefulness of the system. At the Wylam and Wear Iron Works the writer has introduced an arrangement by which the blast is heated by means of the waste heat from the coke ovens.

SHAPE OF THE BLAST FURNACES.

NOTE TO TEMPERATURE OF BLAST.—Since this part was printed Messrs. Cochrane have informed the author that they experience no difficulty in maintaining a temperature of 1150° in Cowper's Stoves, and that they thereby effect an economy of five cwt. of coke in the blast furnace on the ton of iron, as compared with the furnaces using air heated in the ordinary way. Messrs. C. also state that in any future furnaces they propose using this form of apparatus.

In this form the iron is tapped, and the slag allowed to run from the back as well as from the front of the furnace. At the Stockton Iron Works, where the system has been tried, the major axis of the ellipse is 12 feet, and the minor $5\frac{1}{2}$ feet in the hearth—the higher part of the furnace (which is an old one altered) remains circular. The owners do not find it expedient to work it from both sides, as is proposed by the patentee, neither has it the large dimensions he recommends. It is, therefore, premature to offer any opinion on the merits of the plan from the experience of this district, which, however, hitherto has not been such as to warrant the conclusion that a departure from the old shape is advantageous. The blast in the North of England is introduced generally by three or four tuyeres, at a pressure varying from three to four lbs. per square inch, and at a temperature of about 600° to 700° F. The production of a furnace is from 200 to 220 tons weekly, although more than this quantity has been frequently obtained.

QUALITY OF IRON FROM CLEVELAND IRONSTONE.

Notwithstanding the composition of the slags already spoken of, the furnaces drive with great ease and rapidity— the cinder flowing, when the make is foundry iron, perfectly liquid, and of an intense white heat.

For foundry purposes the Cleveland iron was at first objected to from its chilling quickly in the "ladle," when compared with the makes of Scotland, and producing more "scum" than the metal from that country.

The writer had this scum analysed at the Clarence Works, and found it to consist of—

Silicate of iron	42·10
Protoxide of iron	8·32
Iron	42·02
Carbon	1·93
Protoxide of manganese	2·82
Lime	·49
Magnesia	·10
Phosphorus	1·11
Sulphur	·23
Titanic acid	·88
	100·00

The furnaces of this district have little tendency to produce what is technically known as "glazy iron." Some years ago one of the Clarence furnaces, however, did run a quantity of this kind of metal. Two samples of it were analysed, and their composition was ascertained to be as follows:—

	No. 1 Pig.	No. 1 Pig.
Iron	88·18	90·70
Carbon combined	·79	·71
Ditto uncombined	2·59	2·68
Silicon	5·13	5·13
Manganese	·77	·56
Sulphur	·17	·23
Phosphorus	1·12	1·12
Titanium	·26	·18
Calcium	·22	·20
Magnesium	·06	·03
	99·29	101·54

Authority .. .. Carence Laboratory.

Silicon evidently constitutes the chief difference between the two samples given above and the iron usually produced in the neighbourhood.

The composition of fifteen samples of ordinary iron smelted from the Cleveland lias stone is exhibited in the annexed table of analyses. These examinations, with two exceptions by Mr. Crowder, have all been performed in the Clarence Laboratory.

	Clarence. No. 1 Pig.	Clarence. No. 1 Pig.	Clarence. No. 1 Pig.	Tees. No. 1 Pig.	Cleveland. No. 1 Pig.	So. Bank. No. 1 Pig.
Iron	93·030	92·68	94·13	92·40	92·43	92·57
Carbon combined ...	·480	·78	·93	·44	·32	·47
Do. uncombined	2·830	2·43	2·34	2·78	3·43	2·89
Silicon	2·310	2·72	2·57	3·71	1·70	1·76
Manganese	·576	tr.	·31	·42	·30	·44
Aluminium	tr.	—	—	—	—	—
Calcium	—	—	—	—	·05	·03
Magnesium	—	—	—	—	·01	·01
Titanium	—	—	—	·20	·56	·51
Sulphur	·040	·25	tr.	·16	·13	·12
Phosphorus	·300	·30	·30	1·20	1·24	1·29
	99·566	99·16	100·58	101·31	100·17	100·09

	Clarence. No. 3 Pig.	Clarence. No. 3 Pig.	Clarence. No. 3 Pig.	Clarence. No. 4 Pig.	Clarence. No. 4 Pig.	Tees. No. 4 Pig.
Iron	93·96	93·66	92·35	94·64	91·55	93·84
Carbon combined ...	·43	·28	1·24	·26	1·26	·22
Do. uncombined	2·67	3·13	·68	2·45	1·06	2·72
Silicon	2·70	·88	1·80	1·87	1·84	2·16
Manganese	·52	·37	·81	·93	1·06	·50
Aluminium	—	—	·36	—	·27	—
Calcium	—	·30	·93	—	·44	·45
Magnesium	—	·02	·24	—	·15	tr.
Titanium	·25	·14	—	—	—	·09
Sulphur	·10	·17	·04	tr.	·80	·26
Phosphorus	·72	1·23	1·55	1·00	1·57	·83
	101·35	100·18	100·00 Crowder.	101·15	100·00 Crowder.	101·07

	Clarence. Mottled.	Clarence. White.	Clarence. White.
Iron	93·59	97·30	97·036
Carbon combined ...	·85	·90	·788
Do. uncombined ...	2·70	1·06	
Silicon	·56	·11	·400
Manganese	·79	·11	—
Aluminium	—	—	—
Calcium	·26	·15	—
Magnesia	·07	·06	—
Titanium	—	—	—
Sulphur	·35	·96	·342
Phosphorus	1·05	·26	1·434
	100·22	100·91	100·00

From the following summary of some of the experiments on iron, undertaken by the War Department, an idea of the important question of relative strength may be gained. It is only fair to add that these trials were made soon after the works on the Tees commenced operations, since which time the qualities of the ore and its mode of treatment are better understood.

Kind of Iron.	Qual.	S.G.	Breaking Weight, tensile test. lbs.	Breaking Weight, transverse. lbs.	Deflection.	Breaking Weight, torsion. lbs.	Angle torsion.	Force required for crushing. lbs.
Whitehaven—Hematite Foundry	1	7·097	14233	4644	·161	3724	7·2	52136
	3	7·214	17751	5105	·120	4182	5·8	82265
	4	7·196	17566	6100	·152	4977	4·9	82583
Butterly—clay ironstone	1	7·141	23388	7106	·145	7346	9·3	88488
	2	7·078	18970	6077	·128	6011	7·5	74743
	3	7·126	23265	6692	·130	6940	7·5	91663
Ystalyfera—clay do. anthracite ...	1	7·165	25172	7848	·163	6704	12·2	87457
	2	7·157	26758	7944	·196	6176	9·6	90874
	3	7·150	24533	7228	·166	5719	8·8	88772
Blenavon		7·163	26766	7947	·182	5487	6·1	105202
Blenavon cold blast ...	1	7·137	25456	7493	·171	5034	9·	91897
	3	7·158	23906	7600	·191	5674	10·2	87358
Cleveland—Stockton Furnaces... ...	1	7·148	25810	7159	·136	5872	4·2	99526
	2	7·135	22271	6932	·134	6305	5·7	87063

From these figures it would appear that the iron from this northern locality stands very well even when contrasted with some of the best brands of the kingdom. A large founder at Middlesbrough states the Cleveland iron to be strong in the lower classes, viz., Nos. 3 and 4. A bar 2 in. × 1 in., with bearings 3 feet apart, carried 27 to 30 cwts. Under tension, bars having a sectional area of one centimetre, bore 35 cwts. before fracture occurred. In melting for the foundry, the same authority states 2 to 2½ per cent. to be the loss on pig iron obtained from Cleveland stone.

At the Clarence Works the following experiments were undertaken with bars to ascertain the breaking weights. The bars were 2 in. × 1 in., and supported on bearings three feet apart:—

Quality of iron in bar. No. 4 Deflection.		Breaking Weight. Cwts.	Qrs.	Llbs.
No. 1	·65 in.	29	2	22
2	·62 „	28	2	22
3	·60 „	30	0	22
4	·56 „	30	0	22
5	·59 „	27	2	22
6	·60 „	29	0	22
7	·62 „	29	0	22
8	·55 „	28	2	22
9	·52 „	28	2	22
10	·55 „	29	2	22
Average ...	·586	29	0	22

Quality of iron in bar.	No. 4 Deflection.		Breaking Weight. Cwts.	Qrs.	Lbs.	
No. 4 iron	10 others...	·609 in.	28	0	5	
4 „	10 „ ...	·593 „	28	2	27	run from No. 2 pig.
4 „	10 „ ...	·593 „	28	2	12	run from No. 3 pig.
	Mottled.					
No. 1 ...	... ...	·058 „	31	2	22	
2 ...	... ...	·054 „	29	2	22	
3 ...	... ...	·048 „	27	2	22	
4 ...	... ...	·041 „	26	2	22	
5 ...	... ...	·046 „	27	2	22	
6 ...	... ...	·048 „	29	2	22	
	Average ...	·049	28	3	12	

EFFECT OF MANGANESE IN THE BLAST FURNACE.

The experiments of Mons. Caron in ascertaining the effect of manganese on pig iron, which he found sensibly to reduce the amount of sulphur, led the writer to try the effect of it in the Clarence furnaces. The results, in a chemical point of view, are not devoid of interest, inasmuch as they afford some indication of the behaviour of this metal under the treatment of an iron furnace. The ore itself was poor in manganese; the composition was as follows :—

Silica	25·00
Peroxide of iron	24·30
Peroxide of manganese	37·19
Oxide of do.	8·51
Loss by heat	5·00
	100·00

The iron produced gave by analysis for different qualities as follows :—

	No. 1 Pig.	No. 2 Pig.	No. 3. Pig.
Carbon	2·94	2·90	3·30
Silica	2·50	3·53	3·80
Manganese	1·75	2·31	2·45
Sulphur	·292	·247	·254
Phosphorus	·416	·860	·867

As far as the two last mentioned elements are concerned, the addition of manganese in the furnace does not appear to have effected much change, but it is quite possible that the increase of this metal may, when the iron is remelted for the founder, remove a portion of the sulphur. Mons. Caron ascertained that this change occurred when manganese was fused with iron containing sulphur. Want of opportunity has prevented this examination from being pursued.

The slag was of the following composition while the furnace was working with the manganese ore :—

Silica	29·25
Alumina	19·25
Lime	38·25
Magnesia	·60
Protoxide of iron...	1·04
Do. manganese	8·76
Sulphur	2·16
Oxide titanium	·75
	100·06

By calculation it was ascertained that for 100 parts of metallic manganese introduced into the furnace,

There came out in the iron	9·5
In the slag...	87·6
Leaving unaccounted for	2·9
	100·0

These figures require a little modication, difficult to define, arising from a varying amount of manganese being found both in the iron and in the slag of furnaces using Cleveland ironstone alone.

USE OF THE WASTE GASES.

The waste gases are employed for raising steam and heating the blast, but on the use of this mode of economising coal there still exists a considerable diversity of opinion. Extra consumption of high-priced coke and irregularity of working in the furnaces themselves, is not in every case a commercial equivalent for the inferior small coal saved, and labour in firing boilers, &c., avoided. In the writer's opinion there is some force in the objection; at the same time his own experience, after incurring great expense in the necessary gas apparatus, leads him to persevere, in the hope that even the objections he admits to exist, will vanish with the knowledge which time and patience alone can secure.

It is, however, reasonable to suppose, as far as a mere question of fuel is concerned, that the combustion of the carbonic oxide at the top of a furnace must heat the materials to a greater or less extent, and whatever this may amount to will be a saving *pro tanto* lower down the furnace.

To ascertain, if possible, what amount of heat was really imparted to the contents of a blast furnace by the combustion of the carbonic oxide at the top, an examination has been made within the last few days of two furnaces at the Clarence Works, one open-topped, and the other close-topped. At the former the gases were burnt, and from the latter they were conducted away unconsumed. Both furnaces were of the same construction, and both were using materials similar in quantity and quality, and producing the same kind of iron. In both instances the temperature was taken 8 feet below the charging plates.

At the close-topped furnace the following results were obtained:—

	H. M.		Deg. F.	
Time of observation...	... 2·25	Temperature ...	890	
	2·31	... ...	1040	
	2·40	... ...	1040	
	3· 5	... ...	1107	
	3·50	... ...	1240	
Put on 56 cwts. materials ...	3·20	... ...	1240	
	3·30	... ...	1299	Mean ... 1121 F.

Day following.

	H. M.	H. M.	H. M.		
Time of observation ...	3·20 ...	3·20 ...	3·45		
Temperature	1175 ...	1227 ...	1275	......	Mean temp. 1226
Put on 76 cwts. materials	...	...	... ...	......	Temp. ... 1240

Day succeeding.

	H. M.	H. M.	H. M.	H. M.		
Time of observation ...	3·20 ...	3·30 ...	3·35 ...	3·55		
Temperature	1305 ...	1282 ...	1282 ...	1415	Mean ...	1321
Put on 30 cwts. materials, temperature ...	4·5 ...	— ...	— ...	—	Mean ...	1438
Ditto 74 ditto ...	4·20 ...	— ...	— ...	—	Mean ...	1438

The mean of these observations indicates 1200° as being the probable temperature of a close-topped furnace, 8 feet below the charging plates.

An attempt was then made to ascertain the temperature of the gases at a point 8 feet below the charging plates of the open-topped furnace. One observation only was obtained, which indicated 1692°.

In all these experiments the temperature was ascertained by heating a cylinder of copper of a given size, and ascertaining the effect it had on an accurately-measured quantity of water. In the case of the open-topped furnace, the temperature was so high that this apparatus became unmanageable; the copper getting so hot that the water was thrown violently out of the vessel containing it. Looking at the single observation obtained and subsequent appearances, the temperature of the gases in an open-topped furnace will probably be about 1800°, or 600° above that of the close-topped furnace, the datum line in each case being as before stated 8 feet below the charging plates.

TEMPERATURE OF ESCAPING GASES FROM FURNACES.

Scheerer gives 572° F. as the temperature of the upper zone of a blast furnace. The writer recently made the following examination of the temperatures of different furnaces working with close tops.

Clarence No. 5 furnace, 48 feet high, making No. 4 iron.

	H. M.			
Full	2·0	temperature of escaping gases,		558° F.
	2·25	ditto	ditto	850°
Put on 75 cwts. materials ...	2·35	ditto	ditto	580°

Same furnace making Nos. 2 and 3 iron.

	H. M.			
Full	2·0	temperature of escaping gases,		710°
	2·10	ditto	ditto	840°
	2·20	ditto	ditto	940°
Put on 25 cwts. materials ...	2·30	ditto	ditto	710°

Walker No. 4 furnace, 42 feet high, making No. 4 iron.

	H. M.			
Full	2·0	temperature of escaping gases,		690°
	2·10	ditto	ditto	800°
Introduced 33 cwts. materials	2·20	ditto	ditto	670°

Middlesbrough No. 2 furnace, 42 feet high, making white iron.

	H. M.			
Full	2·0	temperature of escaping gases,		519°
	2·20	ditto	ditto	960°
Put on 90 cwts. materials ...	2·30	ditto	ditto	469°

The mean temperatures will be as follow :—

Clarence, making No. 4 iron	710°
Ditto, making No. 2 iron	825°
The mean temperature of the tube conveying the gas from four furnaces was	808°
Walker, making No. 4 iron	740°
Middlesbrough, making white iron	715°

The object of these figures is to show that taking Scheerer's statement as our guide the whole of the furnaces alluded to are working to a loss.

It is obvious that there is an escape of heat capable of preparing an additional quantity of material for treatment in the reducing and fusing zones of the furnace. The obvious method of making this heat available is by increasing the height of the furnace itself. This, however, has its limit, varying probably with the nature and size of the materials used. If, for example, the fuel is easily crushed, or the "mine" is small or easily rendered so, then the altitude of the column containing it must not be above that which will permit the blast to enter freely and preserve, as far as possible, an equal temperature over every horizontal section or zone of the materials.

It is more than probable that the limits of extreme height have been already reached by experience in other localities, the ironmaster there being guided by the peculiar characteristics of his own minerals.

The iron furnaces in Cleveland work under a totally different set of circumstances to those of Staffordshire, for instance, where the coke is friable and the mine small. Our coke is endowed with great hardness and capability of resisting pressure, and our ironstone, worked in great blocks, is sufficiently large to permit a free passage of air through a much higher column than otherwise would be the case.

Messrs. Bolckow and Vaughan have actually put this to the test of practical proof by erecting a furnace seventy-five feet high. Upon one occasion, in making No. 4 iron, the gases were escaping at a temperature of 467° just after charging, and 665° when ready for its charge, or a mean of 517°; the reduction of something like 200°, being due no doubt to the increased burden which this higher furnace was actually carrying.

Economy of fuel in the blast furnace is of twofold importance—first, from its direct action in reducing the cost of making iron; and secondly, as the superiority and quality possessed by charcoal iron over that smelted by pit coal, consists, in all probability, in the greater amount of impurity contained in the latter description of fuel, it obviously becomes a matter of consideration to employ as small a quantity of coke as possible, so as to diminish the weight of foreign matter introduced into the furnace. Hence any system interfering with these conditions requires close and careful watching on the part of the ironmaster.

MAGNETIC IRONSTONE OF ROSEDALE ABBEY.

Hitherto our observations have been confined chiefly to describing the natural and metallurgical features of the Main bed of ironstone in Cleveland, but as there are some matters of interest connected with the Top seam, a short notice of it here may not be out of place.

This seam of the Lias formation (which is either the Top seam or very near it in geological position), has been wrought in two or three places, but by far the most important workings are the mines at Rosedale Abbey. The samples, Nos. 1 and 2, are analyses of the Rosedale Abbey ironstone. No. 4 is the Top seam from Ingleby

	No. 1. Blackstone.		No. 2. Bluestone.		No. 3. Ingleby.
			33·85 Fe O	......	41·14 Fe O
Oxide of iron	64·90	......	32·67 $Fe^2 O^3$	......	7·07 $Fe^2 O^3$
Oxide of manganese	—	......	·69	......	·94
Alumina	9·25	......	3·15	......	4·71
Lime	3·53	......	2·86	......	3·32
Magnesia	·99	......	—	......	3·34
Potash	—	......	trace	......	·20
Carbonic acid	—	......	10·36	......	26·00
Silica	5·70	......	6·95	......	7·37
Loss by heat	16·15	......	1·59	......	—
Sulphur	—	......	·03	......	·08
Phosphoric acid	—	......	1·41	......	1·36
Carbonaceous	—	......	·84	......	·38
Water	—	......	3·76	......	3·86
	100·52		98·16		99·77
Authorities	W. Crowder.		J. Pattinson.		Clarence Laboratory.
Metallic iron	45·43	......	49·20	......	36·95

The Rosedale stone is chiefly smelted at Ferry Hill furnaces, and to some extent as a mixture at other works. In quality the iron is much like that which is obtained from the main beds of ironstone.

The Ingleby stone is a portion of the Top seam, and, being thin and expensive to work, is now abandoned. A few hundred tons were smelted without admixture at the Clarence Works. The content of iron was verified as being superior to the ordinary Cleveland Main seam, but the metal in quality did not differ from the usual make of the district.

WEARDALE ORES.

The Weardale ores, from the quality of iron produced by their use, require some separate notice. They are found in the veins of the mountain limestone, either as sparry or spathose carbonates, or as hydrated peroxides; the latter, no doubt, resulting from the joint effects of atmospheric and aqueous action on the former. The following information, communicated by Mr. Attwood, shows the composition of both varieties:—

	Spathose. Dr. Percy.		Hydrated Peroxide. Dr. Percy.	
Protoxide of iron	49·77	......	—	
Peroxide of iron	·81	......	71·11	
Protoxide of manganese	1·93	......	6·60	
Lime	3·96	......	·56	
Magnesia	2·83	......	1·90	
Alumina	—	......	·40	
Carbonic acid	37·20	......	·13	
Sulphur	0·04	......	—	
Phosphoric acid	trace	......	·22	
Water	0·30	......	12·40	
Insoluble residue	3·12	......	6·32	{ Si 4·0, Al 1·97
Protoxide copper	—	......	trace	
	99·96		99·64	
Metallic iron	38·95	......	49·78	

Dr. Richardson gives the following as the composition of a specimen of Weardale spathose ore:—

Iron ...	44·73
Lime and magnesia	3·95
Silica	·95
Loss by heat	35·50

The character of the iron produced from the above ores is of a marked kind, highly crystalline, and affording bar iron of a very excellent quality. Recently Mr. Attwood has succeeded, he states, by a plan of his own, in obtaining very good steel from the iron.

The composition of a description of iron coming so near in its properties to that of charcoal iron, as it does, is of sufficient interest to justify attention being drawn to it. The following table shows analyses of both foreign and Weardale iron:—

	No 1. German. Spiegel Eisen.	No. 2. German. Spiegel Eisen.	No. 3. Swedish.	No. 4. Weardale.	No. 5. Weardale.	No. 6 Weardale. White Spiegel.
Iron	82·11	98·655	95·27	93·01	99·510	96·775
Carbon	4·77	·210	4·02	4·10	·065	2·092
Silicon	·82	1·062	·08	·23	·140	·882
Manganese	11·12	—	·10	2·37	—	·021
Sulphur	·74	trace	·30	·21	—	·229
Phosphorus	·13	trace	·05	·07	trace	—
Copper	·31	—	—	·01	—	—
	100·00	99·927	99·82	100·00	99·715	99·999
Authorities ..	Dr. Percy.	Mitchell and Richard.	Dr. Percy.	Dr. Percy.	Mitchell and Richard.	Washington Laboratory, by Mons Brivet.

Dr. Percy afterwards having reason to think the proportion of sulphur, as given in his analysis, was too high, repeated the examination, and found it only ·03 per cent. in Weardale spiegel eisen. The slag from the furnace where the specimen No. 5 was made contained:—

Silica	36·80
Alumina, little oxides of iron and of manganese	13·80
Lime	46·00
Magnesia	2·54
Soda and potash, estimated as the difference ...	·86
	100·00

The coke used at the Weardale Company's furnaces is that from the bottom of our coal series, and which, as a rule here, as in some other coal-fields, appears the best adapted for iron smelting, owing no doubt to freedom from sulphur. The subject is of interest, as showing that the results obtained by the use of charcoal abroad, can be very closely imitated when suitable ores, and mineral coal of great purity is the fuel employed.

CUMBERLAND HEMATITE.

The rich hematites of the Whitehaven district approach in some cases to nearly a pure peroxide of iron.

The following indicates their composition :—

	Cleator.	Cleator.
Peroxide of iron	90·58	95·16
Protoxide of manganese	·10	·24
Silica	7·05	5·66
Alumina	1·43	·06
Lime	·71	·07
Magnesia	·06	—
Sulphur	·03	trace
Phosphoric acid	trace	trace
	99·96	101·19
Authority	School of Mines.	
Metallic iron	63·25	66·61

The following analysis shows the composition of iron from the Cleator furnaces—

Iron	93·94
Carbon	4·18
Silicon	1·92
Manganese	·02
Calcium	·12
Magnesium	·06
Sulphur	·05
Phosphorus	·08
	100·37
Authority	Clarence Laboratory.

This ore and that from Ulverstone are brought, to some extent, to the east coast for admixture with the Cleveland stone.

IRONSTONES FROM REDESDALE AND HARESHAW (MOUNTAIN LIMESTONE), AND FROM CONSETT, NEAR SHOTLEY BRIDGE (COAL-MEASURES).

These ironstones having been incidentally mentioned, the following analyses by Dr. Richardson, may be of interest :—

	Redesdale.	Hareshaw.	Consett, Shotley Bridge.
Iron	34·86	36·51	36·68
Lime and Magnesia	9·00	11·90	4·65
Clay	14·00	7·15	15·05
Loss by heat	31·02	34·07	31·91

In each case, no doubt, the stone was a perfectly clean sample, quite free from adhering shale, which will account for the difference of metal between the analyses and the actual yield in the furnace, as formerly stated.

STATISTICS OF THE PIG IRON MANUFACTURE IN CONNECTION WITH THE NEWCASTLE AND DURHAM COAL-FIELD.

The following figures, extracted from the statistical returns of the Geological Survey, afford probably the readiest mode of imparting a correct idea of the extent and rate of development of the iron mines now under consideration.

In September, 1850, the first ton of stone was worked from Eston Hill for trial at Witton Park Works. Previous to this the valley of the Esk, and, to a small extent, the coast, furnished the produce of the Lias beds. Subsequently the quantity raised on the coast was increased a little, in consequence of the seam near Skinningrove being recognized as containing more iron.

	Esk Valley. Tons.	Coast. Tons.	Cleveland Hills. Tons.	Total. Tons.
1855	55,000	50,000	865,300	970,300
1856	48,000	57,164	1,141,448	1,246,612
1857	Not properly separated after this, but most of the increase may be set down as being the produce of the Cleveland Hills.			1,414,155
1858				1,367,395
1859				1,520,342
1860				1,471,319
1861				1,242,514*
1862	25,000	98,900	1,566,066	1,689,966

CUMBERLAND ORE.

	Smelted at Newcastle or Middlesbrough.	Smelted in Cumberland.	Exported to other Places.	Total Tons.
1854	46,785	24,000 estimated	261,257	332,042
1855	37,192	24,106	139,490	200,788
1856	41,450	39,617	168,080	278,147
1857	44,489	56,511	222,812	323,812
1858	57,040	67,248	207,254	331,542
1859	77,200	79,152	243,954	400,306
1860	81,240	128,149	257,462	466,851
1861	65,555	117,654	288,885	472,094
1862	55,838	119,285	357,997	533,120

	Weardale. Brown Hematites and Carbonates.	Newcastle. Claystone.	Cumberland. Alston.
1858	—	1,084	17,094
1859	—	—	1,871
1860	—	—	—
†1861	91,000	—	—
1862	124,750	—	820

* The Government Returns are 111,253 tons short of the actual weight this year.
† The Government Returns are incorrect, only giving 10,750 tons per 1861.

A very large quantity of hematite is obtained from the neighbourhood of Ulverstone, a portion of which is smelted with coke from the Durham Coal-field, while some of the ore itself is brought to mix with the Cleveland ironstone. The following figures indicate the importance of the iron trade of Ulverstone:—

	Carried to Newcastle or Middlesbrough.	Smelted at Ulverstone.	Exported to other Places.	Total. Tons.
1861	11,838	118,759	388,583	519,180
1862	3,548	167,634	388,209	559,391

The following statement gives at one view the number of furnaces on the east coast, existing previous to the recent extension of the iron trade in connection with the Cleveland ironstone worked from the neighbourhood of Middlesbrough, with other particulars of interest connected with its present condition and future prospects:—

Name of Work.	Owners.	Furnaces previous to A.D. 1850.	Furnaces existing 1st Sept., 1863.	Building or projected 1st Sept., 1863.	Furnaces in Blast. 1st Sept., 1863.
Lemington	Tyne Iron Co.	2	2	—	1
Birtley	Birtley Iron Co.	2	3	—	3
Wylam	Bell Brothers	1	1	—	1
Walker	Losh, Wilson, & Bell	2	5	—	2
Redesdale	Redesdale Iron Co.	2	dismantled	—	0
Hareshaw	Hareshaw Iron Co.	3	dismantled	—	0
Consett	Derwent Iron Co.	14	14	—	6
Towlaw and Stanhope	Weardale Iron Co.	6	6	—	4
Bedlington	Longridge & Co.	2	2	—	0
Witton Park	Bolckow & Vaughan	4	4	—	4
Middlesbrough	Bolckow & Vaughan	—	3	—	3
Eston	Bolckow & Vaughan	—	9	—	9
Clarence	Bell Brothers	—	6	2	5
Tees	Gilkes, Wilson, & Co.	—	5	—	4
Ormesby	Cochrane & Co.	—	4	—	4
Claylane	Elwin, Malcolm, & Co.	—	3	3	3
South Bank	Elwin, Malcolm, & Co.	—	3	3	3
Stockton	Holdsworth & Co.	—	3	—	3
Norton	Warner, Lucas, & Barrett	—	3	—	3
Tees Side	Hopkins & Co.	—	2	—	2
Thornaby	Whitwell & Co.	—	3	—	3
Normanby	Jones, Dunning, & Co.	—	2	—	2
South Durham	South Durham Iron Co.	—	3	—	3
Felling, River Tyne	Pattinson & Co. & Bell Brs.	—	2	—	0
Jarrow, ditto	Palmer & Co.	—	4	—	3
Wallsend, ditto	Palmer & Co.	—	2	—	0
Bradley	Richardson & Co.	—	4	—	0
Washington	Washington Chemical Co.	—	1	—	0
Wear	Bells, Hawks, & Co.	—	1	—	1
Ferry Hill	James Morrison	—	3	—	3
Seaham	Marchss. of Londonderry	—	2	—	2
Hinderwell	Hinderwell Iron Company	—	1	—	1
Haltwhistle	...	—	1	—	0
Brinkburn	...	—	1	—	0
Beckhole	Bagnall & Co.	—	0	2	0
Newport	B. Samuelson	—	0	3	0
Eskdale Side	...	—	0	2	0
Glazedale End	...	—	0	2	0
		38	108	17	78

The furnaces working hematite ore on the west coast are as follows, taken from the Geological Survey:—

	Furnaces Built.	Furnaces in Blast.
1861—Cumberland	13	8
Lancashire	12	10
1862—Cumberland	13	7
Lancashire	14	11

According to the same authority, the following figures embrace an account of the production of pig iron from the furnaces alluded to in this paper:—

	1860. Tons.	1861. Tons.	1862. Tons.
Northumberland, using chiefly Cleveland stone	69,093	73,260	46,586
Durham, using chiefly Cleveland stone	340,921	312,030	337,218
North Riding of Yorkshire (Cleveland)	248,665	234,656	283,398
	658,679	629,946	667,202
Cumberland	87,950	55,165	103,455
Lancashire	81,250	109,377	138,563

MALLEABLE IRON.

Malleable iron was, of course, the description of metal produced by all those bloomeries, mentioned in a previous section of this paper, as is indicated by the heaps of scoriæ found near Roman stations, monastic establishments, and other places. Coming down to more recent times, it is obvious that in a country where, comparatively speaking, there would be a considerable consumption of wrought iron, there was necessarily thrown into the market a corresponding quantity of old or scrap iron. With cheap fuel, and water-power in sufficient quantity to drive small hammers, forges were erected at various suitable localities, such as Swalwell, by Crowley and Co.; Beamish and Lumley, by Hawks; Bedlington and at various other places. It is needless to say the weight of metal so manufactured was small. The next stage in the manufacture of malleable iron was the erection of slitting mills in different places commanding water-power; but when or where first established the writer can scarcely determine. By the kindness of Mr. Stephen Hawks, who has searched through the books at the Gateshead Iron Works, he has ascertained that the slit-rods used there in 1772 appeared to be all brought from London, and probably were manufactured in Wales or the Midland Counties.*

* From information communicated by Mr. S. Hurrell, it would appear that, in all probability, the slit-rods imported to the Gateshead Works were from the mills of a Mr. Reynolds, in Shropshire.

Silt-rods were first made in this neighbourhood from hammered bars; indeed, the writer was informed by the late William Losh, one of the founders of the firm of Losh, Wilson, and Bell, that he erected a slitting-mill near Newcastle, and the iron he used was bars brought from Sweden. This would probably be about the year 1800. Cort patented the rolling of bar iron in the year 1783, and Mr. Stephen Hawks, in an old letter-book of 1799, finds Mr. William Hawks writing, "We will certainly roll the iron to the dimensions you mention," so that probably rolling-mills were introduced in the neighbourhood of Newcastle a very short time after their invention by Cort. In the year 1800, according to information received from Mr. G. C. Atkinson, a small mill was erected at Lemington.

Mr. William Longridge states that his father commenced the Bedlington Works in 1809, the river Blyth supplying the motive power. At that time a plate of 150 to 200lbs. was considered, he observes, something wonderful to produce. It was here that, in 1820, they rolled the first malleable iron rails, an invention of Mr. Birkenshaw.

In 1827, Messrs. Losh, Wilson, and Bell erected, what at that time was considered in the north, a powerful mill, at Walker, capable of rolling 80 to 100 tons of bars a week. Here, as at all the other works, old scrap iron or common Welsh bars, cut up for re-rolling, were the raw materials used. This firm led the way in extending the operation to the "puddling" of pig iron, a process adopted by them in the year 1833.

The rapid progress in Scotland of the manufacture of pig iron from black band by means of the hot blast, and the cheapness of coal on the Tyne, induced Losh, Wilson, and Bell to increase their rolling power. A second mill was erected in 1838, where rails of the largest dimensions, and tyre bars for the wrought-iron wheels, invented by Mr. Losh, were manufactured.

The old house of Hawks and Company soon after added largely to their means of producing wrought iron. In this they were speedily followed by the Derwent Iron Company, who erected immense rolling-mills at Consett, near Shotley Bridge, and increased largely the capabilities of the Bishopwearmouth Iron Works, which they had previously purchased. There would be in the district, previous to 1850, about 300 puddling furnaces, capable of turning out above 150,000 tons of finished iron per annum.

The following list, compiled from actual returns, shows the number of puddling furnaces now existing in connection with the iron works of the Northumberland and Durham coal-field:—

Works		Firms.	No. of Puddling Furnaces.
Walker	... Messrs.	Losh, Wilson, & Bell	50
Gateshead ...	„	Hawks, Crawshay, & Sons	33
Consett ...	„	Derwent Iron Company	99
Bishopwearmouth	„	Ditto	31
Birtley ...	„	Birtley Iron Company	6
Bedlington ...	„	Mounsey & Dixon	14
Shotley Bridge	„	Richardson & Co.	27
Hive, Jarrow	„	Elliott & Co.	10
Sunderland ...	„	Tyzack & Co.	7
Britannia ...	„	G. Hopper	16
Jarrow ...	„	Palmer & Co.	30
Tudhoe ...	„	Weardale Iron Company	64
Middlesbrough	„	Bolckow & Vaughan	68
Witton Park	„	Ditto	71
Tees Side ...	„	Hopkins & Co.	55
Albert ..	„	Barmingham & Co	45
Stockton ...	„	Stockton Iron Company	20
		Total	646

The united power of all these works will be equal to an annual production of 340,000 tons of finished iron, and probably the actual make during the year 1862 may have amounted to 300,000 tons.

In addition to the quantity of iron obtained by the puddling process, a considerable weight, possibly as much as 10,000 tons per annum, is manufactured from old iron imported from various parts of the kingdom.

At first a much stronger opinion existed in favour of refining pig iron, previous to puddling it, than is the case at the present moment. In fact, it may be said that this mode of working has been all but abandoned, as more wasteful than simply puddling the pig iron direct; and indeed one manufacturer of great experience gives, as the result of his observation, that a sectional inch of boiler plate had its breaking weight actually diminished by interposing the process of refining between the pig and the puddled bar. At the new works no refineries are built, and at the older establishments the refineries are all but discontinued.

There is probably less mill and forge cinders used in the manufacture of pig iron from the lias ironstone, either for bar or other purposes, than in any other iron district in the kingdom, and this obviously from the greater abundance and cheapness of ironstone. The extra loss in puddling and the depreciation of quality in the malleable iron is more than equivalent for any saving in the blast furnace which may be effected by using the forge cinders, into which the greater part of the phosphorus of the pig finds its way. It is also not improbable that the admixture of mill and forge cinders might, with the constitution of the Cleveland ores, be more detrimental to the quality of the bars than is the case in districts smelting other kinds of ironstone. At all events, our bar iron makers seek to avoid any risk of this by its very sparing use.

Some bar iron manufacturers prefer pig having an admixture of a little hematite in the blast furnace, or they seek to secure the advantages resulting from the use of this class of iron by using hematite pig in the puddling furnaces. It is highly probable that some good attends such a course of procedure, as well from the acknowledged excellence of hematite pig as from the advantage that is generally admitted to accrue from using different varieties in the manufacture of malleable iron. The fact, too, that the tendency of the Cleveland iron is towards cold shortness, while that of the hematite is in the opposite direction, increases the probability of the soundness of these views. At the same time, by care in puddling and in the subsequent process, bar iron of a very high class of excellence can be produced from pig obtained from Cleveland ironstone alone.

Messrs. Bolckow and Vaughan have kindly furnished the writer with a series of samples which have been submitted to breaking strains, and the following are the results :—

Experiment.					Tons	Cwts.
No. 1.	Boiler plate $\frac{3}{8}$ in. thick sec.	=	1 in. sq.,	breaking weight,	26	10
No. 2.	Do.	,,	1 in.	do.	27	0
No. 3.	Do.	,,	1 in.	do.	25	0
No. 4.	Do.	,,	1 in.	do.	26	0
No. 1.	Bar iron	,,	1 in.	do.	25	0
No. 2.	Do.	,,	1 in.	do.	25	0
No. 3.	Do.	,,	1 in.	do.	25	10
No. 4.	Do.	,,	1 in.	do.	24	10
No. 5.	Do.	,,	1 in.	do.	24	10
No. 6.	Do.	,,	1 in.	do.	24	0
No. 7.	Do.	,,	1 in.	do.	25	0
No. 8.	Do.	,,	1 in.	do.	25	0
No. 9.	Do.	,,	1 in.	do.	25	0
No. 10.	Do.	,,	1 in.	do.	25	0
No. 11.	Do.	,,	1 in.	do.	25	0
No. 12.	Do.	,,	1 in.	do.	25	10
No. 13.	Do. submitted for 60 hours to a strain of 22 tons, during which time the elongation was $\frac{5}{8}$ of an inch.					

The quality of both the plates and bars tested in these experiments was No. 3, of extra quality.

Not a bad estimate of the inherent excellence of any pig iron may be formed from the quality of bars it is capable of producing and from the loss of weight incurred in the process of puddling. Within the last few days the writer has received from the manager of one of the largest bar iron works in Scotland, a return of the quantity of Scotch pig iron required to make one ton of puddled bar. He gives 22½ cwts. of pig for one ton of refined metal; 21½ cwts. ¾ths refined and ¼th pig to a ton of puddled iron, which is equal to 23½ cwts. of pig per ton of puddled iron. When the pig is not refined but puddled direct, 23¼ cwts. are consumed for one ton of puddled iron. These figures, from personal experience of some years, the writer considers to indicate as good a yield as the Scotch iron is capable of affording. From two separate works using pig iron made from Cleveland ironstone the following returns have been furnished; from one, the produce for the whole of 1862, was 22 cwts. 0 qrs. 16 lbs. of pig to the ton of puddled iron, and for the first six months of 1863, it was 22 cwts. 0 qrs. 17 lbs. at the same work. The second establishment gives for the year 1862, 22 cwts. 0 qrs. 16 lbs. of No. 4 iron to the ton of puddle bar. The loss, therefore, on iron produced from Cleveland ironstone is only about 66 per cent. of that when using Scotch iron, and the quality of the former is such that the preliminary process of refining, as has been already stated, is all but entirely dispensed with.

Many of the forges being, under the circumstances just enumerated, of recent construction, embrace all the latest improvements. Very powerful steam hammers forge down the puddled balls so rapidly into blooms or slabs, that two of these are frequently taken simultaneously to the puddling mill and rolled out by "doubling" into a single bar, of dimensions varying with the subsequent destination of the product.

In the puddling furnaces different materials are employed in different localities for protecting the iron bottoms. In some places the plastic hematite from Lancashire is the substance used, in others limestone is preferred. In most cases, however, "bull dog," *i.e.*, calcined mill furnace scoriæ, ground and mixed frequently with a small quantity of red ore, is found a good covering. This substance is capable of resisting the corroding action of puddling pig, which is more rapid than that of refined metal, or a mixture of refined metal and pig.

The qualities of pig iron used in the puddling furnaces vary with circumstances; for a fibrous quality of bar, No. 4 forge pig gives very satisfactory results. A considerable quantity also of white and mottled iron is worked up in our forges.

Finishing mills of great power have been constructed, capable of rolling rails, bars, angle and girder iron of any section, and of the greatest lengths produced in this branch of manufacture. Sheets of all kinds and plates of the largest dimensions, short of the huge masses of iron now applied to our iron-clads, are also turned out, of excellent quality.

Supposing the make of pig iron in the district more immediately connected with the Cleveland ironstone field to have been 667,000 tons, it will probably have been disposed of as follows :—

	Tons.
For foundry purposes in the neighbourhood, say	150,000
For malleable iron	400,000
Exported elsewhere	117,000
Total	667,000

In addition to the ironstone and hematite consumed on the East coast, amounting, as we have already seen, to about ...	1,870,000
There will have been used in pig and bar iron works, and foundries of coal, say	2,900,000
Limestone at the blast furnaces	500,000
Total weight of materials	5,270,000

The capital employed in mines, blast furnaces, and malleable iron works will be from two to three millions sterling.

The annual amount of wages for miners, furnace-men, and workmen engaged in the mills, forges, &c., say ...	£1,750,000
The dues paid to the railways for carriage on minerals and on iron, will not be far short of	500,000

The activity imparted to our local iron trade by the recent discovery of the Cleveland bed of stone near Middlesbrough has few, if any, parallels in the commercial history of the kingdom. Fifty years ago Staffordshire and Wales had reached great eminence as iron-producing districts. Their powers sufficed at that time to supply the chief requirements of our commerce. Gradually, as this demand increased, their means of production extended, until Neilson's discovery of the hot blast enabled the Scotch ironmasters, five-and-thirty years ago, to bring their rich blackband into competition with the clay ironstone and hematite ores of England.

Enormous as are the quantities of iron produced by the works of the localities just enumerated, it must be remembered that their present condition was the growth of a considerable period of time. Ten years, on the other hand, sufficed to place the iron trade connected with the Cleveland bed of ore in its present remarkably conspicuous position.

The Middlesbrough ironstone was opened out in the latter part of 1850, and in the year 1860 the following numbers indicate the weight of pig iron smelted in the districts quoted for the sake of comparison :—

	Tons.
Northumberland, Durham, and the North Riding of York ...	658,679
North and South Staffordshire	616,450
South Wales	969,025
Scotland (the whole of)	937,000

The figures are from the Geological Survey.

This rapid rate of increase in our local trade has been maintained without the exercise of any influence of a speculative character. New markets had to be sought, increased sources of consumption had to be organized in our own vicinity, and some prejudices had to be overcome, before the new brands of this additional iron district were fairly accepted as an important contribution to the metallurgical industry of the kingdom. Now that this much has been honestly and completely accomplished, we may fairly look for a great extension of those local branches of manufacture in which iron plays an important part. With our cheap fuel, magnificent and improving harbours, and enormous commerce, it is only reasonable to suppose that rolling mills, engineering establishments, iron ship-building and many other similar undertakings will find a place among us, and assist in maintaining, for the North of England, a very honourable rank in those industrial communities which contribute so largely to the welfare and prosperity of the British empire.

Clarence Iron Works, 26th August, 1863.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, SATURDAY, APRIL 2, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

Mr. Howse having read the minutes of the Council Meeting,

The President observed, that the first subject for discussion was Mr. Green's paper on the Anthracite Coal of America.

Mr. Green said, he understood he was mistaken in supposing that the anthracite coal was on the Old-red-sandstone.

Mr. Howse said, that at the last meeting Mr. Greenwell had communicated a paper, which was not yet printed, suggesting that the Anthracite coal was probably not Carboniferous but Oolitic. As Mr. Green had not yet had an opportunity of seeing these objections, the discussion could not conveniently come on till Mr. Greenwell's paper had been printed.

The President said, they were very much obliged to Mr. Green for his specimens.

MINERS' RELIEF FUND IN BELGIUM.

Mr. Morison said, he had nothing further to communicate on this subject. He had hoped to be able to present the report for the last year, but he found he would not be able to get it for a week or two. He should be glad if any practical suggestion could be made as to the working of something of the same kind in England. He thought one statement hardly fair towards the miners of England had been made. It was stated, in one of the newspapers, that the average of wages paid to miners in the north of England was 6s., whereas, in Belgium, the average was only 2s. But that average included the whole of the workmen in the colliery, and not the hewers only.

Mr. G. Baker Forster said, the average was not 6s. but 5s. 2d.

Mr. Morison—In Belgium it is the whole of the persons in the society, including those of thirteen or fourteen years of age.

The President—We know the workmen in Belgium and Prussia do not receive the wages they do here. The hewers average above 2s., but he should think very little above 3s.

ON A "WASH" OR DRIFT THROUGH A PORTION OF THE COAL-FIELD OF DURHAM.

Mr. Boyd produced the plans from which the illustrations of this paper were taken; and suggested that the discussion upon it should be postponed.

Mr. Howse said he should like to read a paper in connection with this subject—on glacial action in these counties. He had some interesting facts bearing on glacial action to bring forward, which he would do if the discussion were postponed.

The President said, it would be desirable to get all the information which they could obtain applicable to other districts, in many of which, no doubt, a similar "Wash" would be found to have taken place.

Mr. Boyd said, he believed that Mr. John Simpson, Jun., had been turning his attention to the subject.

Mr. Simpson said, he would be glad to bring the result of his observations forward by and by. He had sections above Tyne Bridge, but not below. He had a considerable amount of information respecting the Tyne valley towards Ryton and Wylam, bearing on the thickness of the Wash.

The President said that he had several borings on Dunstan Haughs, which might be useful to Mr. Simpson, and which he would forward to him. He might say, without going into the discussion at the present time as to whether the Wash was caused by glacial action or by the motion of water, that there were decided evidences of glacial action in its course. The diagram at Framwellgate showed this. The great feature of this Wash was, that it proceeded in an almost straight line; whereas the present drainage of the country was in a zigzag, or serpentine line, and very considerably above the bottom of the Wash. Between the two points in the neighbourhood of Durham, its course was in a perfectly straight line from one place to the other; whereas in that distance the river Wear diverged to the west, and cut a new channel, as shown by the section, through the solid rock. Now if it had been a Wash of water simply, they would hardly suppose that the level of the water would not have admitted of the current running down the line of the Wash; and, therefore, it would not have been diverted to one side through the solid rock. He only threw this out for consideration before the discussion came on, whether these facts were not in favour of the theory of its being glacial action.

Mr. ATKINSON asked if they were to understand that the excavation made previously to its being filled up with clay was chiefly by means of ice—that the excavation was caused by ice.

The PRESIDENT said, he meant that there was a glacier passing down the valley; that it was not water simply.

Mr. HOWSE said, under all glaciers there was a strong current running continually over the strata lying underneath the ice. That accounted for the great number of rounded stones or pebbles in the "Wash" deposit. The ice was quite perforated by the action of running water over its surface. The water below the glacier was more compressed, and had more force to cut into the soft strata below it. The harder strata were cut and rubbed down by the ice—the stones and sand which were embedded in it giving it a rasping surface.

The PRESIDENT—No doubt there had been a glacier moving with the water, which scraped the stones; but that glacier would be moving at a very slow rate. The current of water produced by such a fall of surface as existed between Durham and Newcastle would run at a very slow rate; and although there would be a current mixed up in connection with the glacier, still that current, in the space that would be left for it, would not be sufficient for the volume of a rapid and large river. Therefore, in some respect, it would resist the strong current, and divert it to one side or the other.

Mr. G. B. FORSTER said, the river Wear cuts into the Wash; and did not that prove that this river must have become a river subsequent to the present formation of the country; when the ice melted, the river would take another course.

The PRESIDENT—If it was a current of water, how could that river go round about Durham, forming a horse shoe, and cut out the solid rock? It would go, more probably, down the course of the glacier.

Mr. G. B. FORSTER suggested, that the river had only been the river Wear since the present surface of the country was made as it is.

Mr. Morison asked if there were any instances of a glacier lying on as level ground as that between Durham and Newcastle.

Mr. G. B. Forster—The bottom of the Wash is not very level.

Mr. Morison said, he believed most existing glaciers were on very heavy slopes indeed. Glacial action required great pressure.

Mr. Atkinson said, he thought that geologists had been sometimes deceived in supposing that certain marks were due to glacial action, which by farmers were said to be only sheep tracks.

Mr. Howse—A farmer might suppose them to be sheep tracks; but that did not prove that they were so.

Mr. Atkinson—Would it not be necessary to suppose some change in the position of the poles of the earth to account for this country having been covered with ice, or some change in the direction of the axis of its rotation?

Mr. Howse said, he did not think so. A change of the oceanic currents would explain it. A channel, wide enough for the equatorial current through Central America, by changing the course of the Gulf Stream, would probably cause drift ice from the Arctic regions to be brought down to Dover Straits.

The President referred to the bend of the River Wear. If the action had been that of water alone, what prevented it from taking a straight course?

Mr. Howse—Only the accumulation of materials deposited from tributary streams across the bed of the Wash. Some of the boulder clay of the Wash was much harder to cut by water than the solid rock itself was. By such accumulations the water would be thrown off from the line of the Wash to the adjoining rocky surface.

Mr. Green said he had experienced the great difficulty of working the clay of the Wash.

Mr. Boyd said, at Ouston Colliery, Messrs. Perkins and Hunt had recently corroborated the idea of the Wash running in the direction indicated by the map, and denuding the Hutton-seam at a point where that fact had not hitherto been proved. They came in contact with the Wash for the whole height of the seam. The Hutton-seam was taken off, and there were large boulder stones in lieu of it. This was in the valley nearly opposite the village of Birtley.

Mr. Morison said, there was an illustration, in a small way, which he had had the opportunity of seeing a week ago. He was in the valley of the Loxley, near Sheffield. The flood had brought down a collection of mud, sand, and stones which filled up the old valley of the river, and the stream had now gone round by a different course. The question was, whether a similar result on a much larger scale had not been produced in the Wash by a flood, or whether it must be solely attributed to glacial action.

The subject then dropped, and the meeting proceeded to consider what was to be done with Dr. Richardson's paper of experiments. It was finally agreed that Mr. Howse and Dr. Richardson should go over it, and that such parts of it should be published as Dr. Richardson and the Council should decide.

The meeting then separated.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, MAY 5, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-ON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

After the minutes of the Council had been read,

The PRESIDENT said, the first subject for discussion was the Anthracite Coal of America. He had received a letter from Mr. Greenwell, which he would read, asking that this discussion might not be closed till the June meeting. If they complied with Mr. Greenwell's request, it would not prevent them from going into the discussion at present.

Mr. GREEN said, Mr. Greenwell, referring to authorities before him—he supposed Lyell and Taylor, had suggested that this Anthracite Coal-field belonged to the Oolitic formation. This conclusion had been come to by Sir Charles Lyell with regard to the Virginian Coal-field, east of the Alleghany Mountains; but he does not mention the Anthracite coal. He further remarked, that Zamias and Cycads are generally characteristic of the Oolitic formation, but that he had not observed any of these fossils, and did not think they were ever found in the Anthracite coal; what he found were similar to the ordinary Carboniferous fossils. Another characteristic of the Oolitic formation is the quantity of marine fossil shells found in connection with it, none of which were observed by him. With regard to the Old-red-sandstone, he was accompanied by one who knew the district, and who pointed out the Old-red-sandstone to him in more than one place.

Mr. HOWSE read the following remarks on Mr. Greenwell's observations:—

NOTE ON MR. GREENWELL'S OBSERVATIONS.

As Mr. Greenwell appears to have some doubt about the exact geological position of the Anthracite coal of America, I may be permitted to bring forward, for the information of the members of this Institute, some proofs of the correctness of the views expressed in Mr. Green's paper, and held by geologists generally. Professor Dana, in his excellent Manual of Geology, states, "that the great Appalachian Coal-field covers part of Pennsylvania, Ohio, Virginia, eastern Kentucky, eastern Tennessee and Alabama. The workable area is estimated at 60,000 square miles. The whole thickness of the formation is 2500 to 3000 feet. The aggregate thickness of the included coal-seams more than 120 feet in the Pottsville and Tamaqua valley, about 62 feet near Wilkesbarre, and 25½ feet at Pittsburg. The area is partly broken up into patches in Pennsylvania, as shown on the map on page 25 *ante*. In the centre of the state, between Pottsville and Wyoming, are the famous Anthracite beds, divided into many distinct patches; and on the western part commences the great bituminous coal-field, which spreads into Ohio, and stretches on south to Alabama."

I was not aware, until I had read Mr. Greenwell's suggestion, that any other opinion than the above had been held on this subject; but on referring to Mr. Taylor's work, at page 74, it is stated that the prevailing opinion about the year 1830 was, "that the Anthracite deposits of America were of older origin than those of the bituminous coal. In fact," continues the same authority, "the presence of Anthracite was, at one time, thought to be conclusive evidence of the Transition or Grauwacke period." The Anthracite coal was, at that time then, according to Mr. Taylor's opinion and statement, considered not newer but older than the true Carboniferous rocks. But Mr. Taylor adds, "by this time (1837) the doctrine of the supposed antiquity of the Pennsylvanian Anthracites had been abandoned by common consent." No doubt the absence of the Lower Carboniferous rocks, corresponding to our Mountain-limestone series, in the Anthracite region, and the position of the coal-seams almost resting on the older Devonian rocks, and the mineralogical appearance of the coal itself, tended to support this early opinion; but it is clear, from these extracts, that neither Mr. Taylor, nor any geologist, ever supposed that the Anthracite coal was newer than the true Coal-measures.

But is there not abundant evidence in Mr. Green's paper itself, supported as his statements are by the excellent specimens exhibited to the Institute, to satisfy any investigator of the true Carboniferous character of this deposit? Mr. Green mentions, *ante* p. 26, that "the thill of many of the seams, especially of those lowest in the series, is clay filled with *Stigmaria,*" and, that "In the slaty shale above the coal, are found numerous beautiful impressions of Sigillaria, Lepidodendron, and other fossil plants"—plant-remains which have, indeed, never been known to occur in other than true Carboniferous rocks. Who has yet heard of a Stigmaria found higher up in the geological series than the Coal-measures?

It is impossible, at sight, to distinguish hand specimens of the conglomerate, mentioned in Mr. Green's paper, from specimens of the Millstone-grit of Durham and Northumberland; but no great stress can be laid on the lithological character of rocks. The Anthracite beds of Pennsylvania are, no doubt, the exact equivalents of the Lower Coal-measures of the Northumbrian Coal-field, as the embedded fossil remains are nearly identical (see Vol. XII., page 209), and the Conglomerate mentioned in Mr. Green's paper is the equivalent of our Millstone-grit.

Further, it may be stated that at present it is doubtful whether the coal of America, formerly referred to the Oolitic period, is of that date. Many of the best American authorities classify the newer coal of Richmond, Virginia, with the Trias or New-red-sandstone. The same obscurity hangs over the exact position of the newer coal deposits of Asia and Australia. The plants of the Triassic and Jurassic periods do not possess distinctive characters sufficiently marked to settle this question; but this is certain, that the Flora of the Triassic period contains no Stigmaria, Sigillaria, or Lepidodendron. These latter, wherever they occur, indicate the presence of true Carboniferous rocks.

On the map, p. 25, the shaded portion indicates the district occupied by the Secondary rocks, in the run or continuation of which the Virginian coal occurs.

Mr. Green said, he had no objection to offer to this note. He quite approved of it.

The President said, the fossils of the American Coal-field were precisely the same as those of our coal-field; the only difference appeared to him to be, that the American strata were of a harder description than our coal strata; but that would not alter, of course, the position of the coal-field with reference to the general arrangement of the Carboniferous rocks; though harder in the one case than in the other, they belonged to the same group of rocks.

Mr. Atkinson said, we had an example of this in our own island. The Welsh Coal-measure sandstones were considerably harder than those in the North of England, in the Coal-measures proper.

The further discussion of this subject was then postponed to the June meeting.

MR. DUNN'S PAPER.

The PRESIDENT said, the next subject for discussion was the paper of Mr. Dunn, "On the Probability of the Extension of the Coal-measures under the Red-sandstone of Cumberland." Mr. Dunn was not present, and he did not know whether they could discuss it in his absence. It was only right that Mr. Dunn should have the opportunity of communicating any further information he might have on the subject. At the same time, he (the President) thought Mr. Dunn ought to have been present, as it was announced in the regular circulars that the paper would be open for discussion. The least members could do was to communicate to the Institute that they could not be present, or give some reason for unavoidable absence.

Mr. GREEN said, it should be known before it was entered in the circular, whether the author of a paper to be discussed would be present.

The PRESIDENT—That might be brought forward at the annual meeting, as a rule to be adopted.

Mr. HOWSE suggested that as the subject of Mr. Dunn's paper was related to that of Messrs. Daglish and Forster's, the discussion of the two might take place together.

This was agreed to.

Mr. T. SOPWITH'S paper, "On the Lead Mining Districts of the North of England," was taken as read.

Mr. HOWSE then read a paper entitled "On the Glaciation of the Counties of Durham and Northumberland." After the paper had been read,

The PRESIDENT said, he had been surprised at the apparent newness of the scratches on several of the specimens exhibited. They were much obliged to Mr. Howse for the trouble he had taken. He thought Mr. Berkley should give them some account of the "Wash" at Marley Hill, which was at a much higher level than the Wear valley Wash.

Mr. BERKLEY said, the Wash had taken so many turns he could scarcely say where it would go to next.

Mr. HOWSE pointed out on the map some peculiarity of the old Wear Valley, which appeared to have gone towards the Tyne by the line of the Magnesian-limestone escarpment. The two valleys of the Wear and the Beamish Burn were really distinct, but they appeared to inosculate near Birtley.

The PRESIDENT said, it would be a desirable thing to get an account of the borings through the clay at the different pits all over the district. There were no secrets with regard to the clay; and he thought one or other of the members of the Institute must possess the borings or sinkings of the entire coal-field. If they had an account of the thickness of the clay in all the borings and sinkings of the district, it would be very valuable, and he thought they could readily obtain them.

Mr. BERKLEY said, he had Norwood and Bewicke Main.

The PRESIDENT—The levels could be got from the Ordnance Survey.

Mr. BERKLEY said, that in passing through the bottom of the Wash they found large stone boulders.

Mr. HOWSE, in reply to a question, said the harder sandstones forming the sides of the "Wash" were stated to be scored horizontally, or nearly so.

Mr. BERKLEY said, they came to boulders of whin beside sandstone.

Mr. HOWSE said, it had been stated, that at Birtley the rocks found had distinct scratches and grooves, and many pebbles that rested on them were likewise striated.

Mr. BERKLEY—In the lowest part of the Wash we have beds of sand lying perfectly level.

Mr. HOWSE said, it was important to distinguish between the boulder-clay and the clay which was a mere washing from the boulder-clay.

Mr. BERKLEY said, they had no clay at the bottom, but there was clay above. It was sand and beds of sand mixed with clayey matter. At the bottom of all they had enormous boulder stones.

Mr. ATKINSON — What was boulder-clay except clay containing boulders? How would they distinguish it otherwise?

Mr. BERKLEY—At the mouth of the Team there are no boulders. It is almost entirely clay without any gravel in it.

The meeting then broke up.

ON

THE GLACIATION

OF

THE COUNTIES OF DURHAM AND NORTHUMBERLAND.

By RICHARD HOWSE.

About the year 1854–5 extensive barings of the Trou-rocks in the neighbourhood of South Shields, previous to quarrying the Magnesian-limestone of that locality for the new pier works, afforded me an opportunity long-desired of examining extensively the character and appearance of the rock-surface under the superficial covering of clay and sand which, at this place, covered the royalty to the depth of five or six feet or more. For a long time my searches for indications of the true rock-surface were unsuccessful, owing to the circumstance of the denudation of the clay-covering in that portion of the quarry first worked, and the consequent defacement and obliteration of the original surface. But as the works proceeded, and the thickness of the clay-covering increased, I was soon gratified with a proof of the former glaciation of nearly the whole of the rock-surface, and the existence upon it, in many places, of a rough angular gravel, and also of large rounded blocks of polished, striated, and scored Mountain-limestone, Millstone-grit, Sandstone, and Basalt; the latter all derived from the higher lands of the county; from the district between the Pennine Range and the East-coast.

On observing the direction of the striæ, and the inclination or slope of this glaciated surface within short distances, it was then for the first time suggested to me that these appearances could not be explained by the opinion generally entertained by English geologists of the stranding of icebergs, and the abrasion caused by large masses of floating ice charged with boulders slowly moving over and grazing the rock-surface in the orthodox direction of N.W. and S.E., for here, within a few hundred yards, were glaciated rocks with the striæ, indicating the movement of the glaciating-agent to the N., to the N.E., and the E.; and not only the most elevated points had been ground down, but the slopes and sides of hollows; and masses of rock projecting above the ordinary level also showed the glacial markings to greater perfection on their sides than on some of the higher points. There was also added, to strengthen this conviction, the fact that the materials accumulated in the extensive deposits of boulder-clay at the mouth of the Tyne could be traced to the higher parts of that river, and that all the extensive accumulations of this material, further to the South, contained specimens of Magnesian-limestone, polished and glaciated, derived from the Magnesian-limestone plateau; such limestone never occurring in the boulder-clay at the mouth of the Tyne, or on the Northumberland coast, except near the outlier of the Magnesian-limestone at Whitley.

It therefore appeared certain, from these facts, that the moving ice, bearing these special boulders which can be traced to their original beds up the Tyne, must have travelled from the West; from the higher ground towards the coast; and that the hypothesis of continental- or land-ice, involving, as it did, the subsidence of nearly the whole island, and afterwards an immense change of climatal conditions to those at present existing, seemed more in accordance with the facts registered on these rocks, and absolutely necessary to explain the appearances of the glaciated surface, and the formation and deposition of the boulder-clay, than the vague and merely-conjectural theory of the stranding of icebergs drifting southwards from some unknown northern locality, and bearing rocky materials not belonging to the countries whence they came, but identical with those to which these hypothetical icebergs had drifted.

SUPERFICIAL DEPOSITS.

The superficial deposits resting on the rock-surface of these counties are so closely connected with the theory of glaciation by continental- or land-ice, that a short account of them is necessary to elucidate this theory.

1. Beds of peat, and submarine forests with fossil remains of oak, alder, mountain-birch, and hazel; horns of *Cervus Alces* and *Cervus Elaphus*, *Bos primigenius*, &c.
2. Rubble transported from moraine heaps of upper valleys.
3. Gravel beds, forming remains of ancient, raised-beaches.
4. Sand, forming elevated mounds along the courses of valleys.
5. Brick clay, with intercalations of laminated-clay, sand, and peat-bed containing skeleton of *Megaceros Hibernicus*, and stems of *Calluna vulgaris*.
6. ? Scandinavian drift, containing angular flints, and small fragments of rock, probably derived from boulder-clay.
7. Boulder-clay or drifted, glacier-moraine containing fragments of *Cyprina Islandica*.
8. Ancient gravel bed resting on rock-surface.

BOULDER-CLAY.

The most important of these, and that which generally rests on the rock-surface, is the covering of clay, of variable thickness, filled with fragments of rock, from the smallest grain to blocks and masses of five or six tons weight. This deposit is also most extensively distributed, having been spread not only over all the lower portions of Scotland and the North of England, but as far South as the chalk range. At the present time its presence in these counties is limited chiefly, though not entirely, to the old valley channels, depressions, and denudations of the rock-surface. Traces of it, showing its former deposition, are visible on all the higher elevations that occur on the coast line, and on the tops of the highest hills of the Magnesian-limestone terrace, but on these heights it is more generally represented by large Mountain-limestone or whinstone boulders than by a regular bed. On the coast line of this immediate neighbourhood, it forms the cliff from St. Mary's Island to Whitley Terrace. The thickness of the deposit is here unknown. In one place near Whitley, the hard sandstone rock on which it rests was ground flat, and strongly grooved and striated with fine parallel striæ. The most conspicuous section, and the one most worthy of notice, occurs between the Low Lights and the Spanish Battery. It rests here on the northern side of the great, Tyne valley, which extended for two miles from the latter locality to the Trou-rocks: it is of an unknown depth. Very thick deposits of it form the sites of the towns of North and South Shields, and the district of Jarrow Slake; and, not to multiply instances, the greater portion of the town of Newcastle is built upon it, of which we have full proof by the number of boulders thrown out in the clay when a sewer, a well, or a railway cutting has to be made. This Tyne valley boulder-clay deserves special mention, because not only is it thickest in this the deepest valley of the district, but the fragments deposited at the present mouth of the river are so large as to have attracted the attention, not of geologists only, but of ordinary observers; and so numerous were the blocks formerly washed out of this deposit, and accumulated on the Black Middens, that it was necessary for the safety of shipping entering the river to have them removed. In one part of this section, near the Spanish Battery, the sandstone underneath the clay is distinctly ground down, but the soft nature of the rock-surface exposed under the other portion of the cliff has not registered any traces of glacial markings.

In one portion of this section, under the Old Barracks, may be distinctly seen an old deposit of gravel, formed chiefly of angular Magnesian-limestone, quartz, granite, and porphyry, very little water-worn. The boulder-clay is here from forty to fifty feet in thickness, and is charged with fragments of rocks of all sizes up to several tons weight. The matrix of this deposit is generally a tenacious, stiff clay, through which the smaller boulders, pebbles, and sand, are indiscriminately distributed; but the larger blocks are arranged in more regular order, as if deposited periodically, though scarcely approaching to a regular stratified arrangement. Some of the small fragments and blocks are perfectly angular, as they were on the day they fell from their proper bed, but others, small and large, have been ground and rubbed, and scored and polished, and striated in a manner not to be described by words, but which some of the specimens exhibited will enable any one better to comprehend. These specimens not only show that numerous fragments of different qualities of coal and shale, both which occur in small pieces, and are often beautifully striated, but also that occasional pieces of Cheviot porphyry, quartz-pebbles, and fragments of granite, derived, probably, the two latter from the Old-red-sandstone conglomerate of the North Tyne valley, and the former from the valley of Reedwater, are also presented to us in these rocks. But the most abundant blocks, and those that are best polished, striated, and rounded, are of Mountain-limestone, and it is this rock that forms the most extensive beds in the valleys from which these blocks are assumed to be derived. Immense blocks, also, of coarse Millstone-grit, and whinstone or basalt from the Great Whin-sill, are too numerous to reckon. The iron-ore and fossils from the Mountain-limestone series—the grits and sandstone of the Millstone-grit formation—the shales, coals, ironstone, and shell-bands of the Coal-measures, are all represented in this typical deposit at Tynemouth. Lately I have been so fortunate as to detect in this boulder-clay small pieces of a marine shell *Cyprina Islandica,* which is, I believe, the only Tertiary fossil that has been found in this deposit.

Proceeding southwards we find another thick deposit of boulder-clay, stretching from the coast near Whitburn nearly to Roker, or in other words filling up the denudation between the Cleadon and the Fulwell Hills. Near Fulwell its thickness, in probably not the deepest part of the valley, has been proved to be about 66 feet at the Fulwell water-works. Further to the South the boulder-clay occupies the coast-line from the North side of the Wear to a distance of more than a mile beyond Hendon. In the two latter localities, in addition to the materials enumerated in the Tynemouth section, there are also numerous fragments of Magnesian-limestone, indicating very clearly the direction of the transporting agent. The fragments of Cheviot porphyry also appear to be more numerous than in more northern localities. As it is quite impossible to enumerate all the localities where this boulder-clay occurs, we may, having drawn attention to the most conspicuous examples occurring on the coast-line of this neighbourhood, mention that it is generally present in all the denuded valleys that run across the Magnesian-limestone terrace, and is seen in cliff-section in many places along the coast and near the mouth of the Tees. Great quantities of fine gravel and beds of sand are often intercalated in the clay of this deposit.

? SCANDINAVIAN DRIFT.

The boulder-clay passes up in many sections on the coast-line into a much purer deposit of tenacious clay, containing few or no pebbles or fragments of rocks; but in a few localities the deposit succeeding the boulder-clay is remarkable for the numerous angular fragments of chalk-flints which it contains. It is this deposit which covers the rocks to the depth of five or six feet at the quarries near South Shields as above mentioned, and the same beds appear also in the same relative position on the North side of the Tyne near Tynemouth. It is also found reposing on the boulder-clay in the neighbourhood of Whitburn. The nearest places from which chalk-flints can have been derived are South from the neighbourhood of Flamborough Head, West from Giant's Causeway, North from the neighbourhood of Aberdeen, and East from Denmark; and it is to this latter locality that in all probability these flints will be traced: the deposit in which they occur appearing to be an extension of the great Scandinavian drift to this Eastern coast of England.

In the beds of clay, stratified beds of sand become more numerous, and in many places—especially along the river valleys—immense deposits of this material, containing stratified lines and false beddings of small coal, form the most conspicuous physical feature. Perhaps there is no place in these counties where this peculiar deposit is seen to greater advantage than in the neighbourhood of Durham. Some of the sections of the "Wash" paper show the thickness of this deposit in this interesting neighbourhood in a clear manner.

RAISED-BEACHES.

In a few localities, on the flanks and at the base of some of the eminences of the Magnesian-limestone terrace, beds of rounded gravel, with rocks derived from the boulder-clay, are deposited in beds round the base of the cliff. Along the coast, near Seaham and Hawthorn, deposits of this kind occur. A remarkable instance of one of these ancient beach formations was exposed on the North escarpment of Fulwell Hills. This has been carefully described by Mr. Kirkby, who has kindly furnished a diagram showing the position of this old cliff and elevated beach, and its relationship to the boulder-clay. A corresponding deposit occurs on the opposite escarpment of the Cleadon Hills, in the form of a bed of gravel, which underlies the village of Cleadon.

An elevated beach, composed of fragments of Magnesian-limestone chiefly, with remains of flints and also pebbles from the boulder-clay, interstratified with beds of sand and grit and a very fine glacial silt, occurs in a section lately made in the Castle-yard at Tynemouth. It contains also the remains of a marine shell, *Cyprina Islandica,* some fragments of which have been also detected in the boulder-clay. This beach deposit rests on a thin bed of clay with pebbles, which appears to be a re-construction of the boulder-clay under which is the proper rock-surface. It reposes on a slope to the west, and contains, as before stated, materials derived from some Magnesian-limestone cliff—from a cliff, in fact, which must have been situated considerably East of the present line of coast. Other deposits of this kind occur in many other localities in the county of Durham.

RUBBLE.

It is well known to the members of this society that the whole of the South-eastern part of the county of Durham is covered, to a great depth, with mounds, or heaps of coarse gravel, rubble, and sand; some of these forming hills of remarkable conformation, and the whole deposit concealing the rock-surface over nearly the whole extent of that district.

This brief description of most of the superficial deposits will help to illustrate the theory I wish to explain. The origin of these different deposits, and the mode in which they have been accumulated and arranged, we hope to show as we proceed.

GLACIATED ROCK-SURFACE.

In as brief a manner as possible I must now mention the localities in these counties where glaciated rocks have been observed.

The first instance I find recorded in the Tyneside Transactions, Vol. I., p. 273, by our lamented friend Mr. Loftus. He mentions in this paper, "that during a geological excursion in the neighbourhood of

Belsay, he was so fortunate as to obtain an opportunity of seeing a surface of the stone exposed to view, over an extent of about half an acre, which had previously been covered by a quantity of earth and rubbish. The strata appeared to dip at an angle of nearly thirty degrees, and on the lowest part of the quarry a bed of detritus rested, upwards of twenty feet in height. My attention was soon directed to the extraordinary appearance of the exposed surface. In the direction of the dip throughout, it was deeply scored and scratched by longitudinal and nearly parallel lines of various width—so deeply, in fact, that on standing at the bottom of the quarry, and looking upwards, one could see the surface irregularly furrowed in a transverse direction, which was evidently occasioned by the depth of the longitudinal grooves or scratches, which had acted with more or less force on different portions of the surface. Many of the furrows were six inches in depth. On looking around in hopes of finding some explanation of the cause of the phenomenon, we perceived that the mass of earth and rubbish resting on the lowest part of the quarry was filled with stones of various sizes—from a yard in diameter to a few inches. Lying on the surface of the quarry were several large blocks, of too great size for the workmen to remove, and which were consequently left remaining there to be broken up. The whole of these had their edges and angles completely worn down, and were scratched on all sides and in every direction, and were frequently also polished; evidently a proof that in causing the scratches and grooves on the surface of the quarry, they had likewise mutually rubbed and ground each other to the state in which we found them. As these boulders are, I believe, all of the same limestone as the quarry, and similar beds among the Cheviot Hills, we may fairly presume that they have not been transported from any considerable distance."

The next recorded observation of glaciated surface is by the eminent geologist, Mr. Tate, of Alnwick, in the same volume of the Tyneside Transactions, Vol. I., p. 348, as follows:—

"The polished and scratched surfaces now to be described were found in a limestone quarry on Hawkhill farm, belonging to Earl Grey. The rocks in this neighbourhood belong to the Carboniferous or Mountain-limestone formation. The section presented at the Hawkhill quarry is as follows, beginning with the uppermost bed:—

	Ft.	In.
1. Red tough clay, with large and many smaller boulders ...	12	0
2. Five beds of blue Carboniferous-limestone, with thin shale partings	19	0

&c., &c., &c.

"The quarry is situated on the high ground which runs nearly parallel with the coast, and which has apparently been elevated by the basaltic protrusion. The slope is towards the river Aln, and on the opposite bank of the river, nearly a mile distant, a similar clay bed to that which lies on the top of Hawkhill quarry is found, but at a lower level.

"Now, immediately below the red tough clay the surface of the limestone bed is polished, scratched, and grooved. An area, twenty feet by six, has been bared in this state; and the same polished and scratched surface appears to extend under the clay. One part of the surface was flat and even, presenting a smooth bright face, like marble artificially polished; other portions were rounded and undulating, but still exhibiting the same mirror-like polish. One part, in particular, was one foot below the general level; but in this and similar cases the angular corners of the higher portions were removed, and a smooth and rounded outline was formed. It is important to notice that the polishing of this surface is very different from the rounding and smoothing of rocks, arising from their attrition on each other by the driving action of tides and currents.

"Besides being polished, the Hawkhill limestone was more or less scratched, the scratches varying both in depth and in length, some being very fine striæ, and a few being grooves one-quarter of an inch in depth. These grooves were parallel, one inch apart, and from six to twelve inches long. Many of the scratches were 1-10th of an inch in breadth, and from one to six inches in length, having a general direction of from N. to S., pretty nearly in the dip of the quarry; but there were also other scratches, several being broad and deep, which were more or less oblique to the general direction; those on the rounded corners of the higher parts of the surface had a tolerably regular direction of from N.W. to S.E. Notwithstanding, however, the exceptional cases, the general direction of the scratches, when observed over the whole surface, could not be mistaken.

"The appearances described are undoubtedly connected with the boulder formation of the district; for in the bed of clay above the polished limestone there are polished blocks and fragments. A large block of limestone, measuring three feet long by two feet broad and two feet thick, embedded in the clay three feet above the limestone bed, was scratched and polished on its under surface, the scratches having a direction as the stone lay of from S.E. to N.W.; this block was not rounded like a water-worn stone. Smaller polished and scratched rocks are numerous on the clay near to the limestone bed; but the number of such polished fragments proportionally diminishes as we ascend higher in the clay deposit. In Scotland, in the Isle of Man, and other parts of England, and also in Scandinavia the same connection is manifested, where the polished and striated surfaces are, there is also the boulder formation."

Much other interesting information is contained in Mr. Tate's valuable paper, and also the mode in which the glaciation has been caused is carefully discussed. The theory of glaciation by glaciers is objected to, and the more generally received one of glaciation by the stranding of icebergs is advocated.

Since the year 1855 repeated opportunities have occurred to me of observing, during the process of baring the Magnesian-limestone rock at South Shields, extensive portions of glaciated rock-surface extending over several acres. The phenomena presented to view here are much the same in detail as those observable in the Mountain-limestone district; but the more extensive exposure of the surface has given greater interest to the observations.

The rock-surface at this locality presents a somewhat uniform level for several miles inland, extending with slight undulations to the foot of the Cleadon Hills, which rise up rather abruptly from this extensive flat, and with a strongly marked ancient cliff-line. There is a very gentle rise from the interior valley towards the coast at this place. So far as the excavations have proceeded these rocks are covered with a deposit of coarse clay, harsh-looking, broken up into prisms, and of a cold bluish colour, containing fragments of sandstone, quartz, porphyry and angular flints. It contains no boulders nor large pieces of rock, but the former are very numerous immediately beneath its under surface. It is generally about six feet thick, and the upper surface presents, when uncovered from the blown sand resting on it, a remarkably level appearance. The rock-surface under this deposit of clay, though showing a general level is, from the variable nature of the limestone and the destruction of the surface by the erosion of water through the bed of clay, somewhat irregular. In the cavities are left small accumulations of true boulder-clay of the usual appearance, large Mountain-limestone and whinstone-boulders glaciated very strongly, and patches of moraine gravel and silt. Over one part of the rock-surface the gravel and blocks formed an elevated lengthened mound for many yards. The rock-surface on the South side of this mound was conspicuously and strongly glaciated, the direction of the striæ being East, and the surface gently sloping towards the sea. The glaciation continued onwards close to the extreme edge of the cliff. On the other side of the mound the glaciated rocks, following the slope of the surface, showed the striæ running to the N.E. Further westward the striæ have a North direction, or towards the bed of the Tyne valley. Not the highest points showed the glacial markings to greatest perfection, but the sides of depressed surfaces, the rising edges of which were always more distinctly striated and polished than the more level portions, at least, these markings are best preserved in such positions. Rocky masses projecting above the general level, *roche moutonnè*, were beautifully polished and grooved all round. One side of a large specimen of this character is deposited in the Newcastle Museum.

At the northern extremity of the denudation between the Cleadon and Fulwell Hills, on the coast near Whitburn, conspicuous striations of the rock-surface have been observed which are the more interesting, as at this locality, those peculiar conglobated forms of Magnesian-limestone form the surface rock. Nevertheless the upper surfaces of some of these are ground down and scratched in the direction of the valley in a very conclusive manner. The deposit resting on these has more the character of glacial-moraine than in some other localities. It is composed chiefly of fragments of Magnesian- and Mountain-limestone, etc., the former predominating, also shale, coal, and porphyry. The boulder-clay is at this point distinctly capped with a bed of clay containing flints, the upper part of which is finely laminated, and containing intercalations of sand with false-beddings of coal very finely and distinctly exhibited.

In the South, near Ryhope, the Magnesian-limestone is seen to be distinctly grooved and rubbed down where the clay and sand have been removed from it, the direction of the striæ following the natural slope of the locality.

The glaciation of the rock-surface under the boulder-clay at Tynemouth and Whitley has already been mentioned. More recently, glaciations have been observed in the quarries in the neighbourhood of Belford, by Messrs. Tate and Douglas, presenting much the same appearances as before described. In the valuable paper on the "Wash" deposit of the Wear valley, the authors distinctly state that the surfaces of some of the harder sandstones, forming the side of this valley, are scored and scratched as if by some heavy body transported over them.

The fine specimens of glaciated rocks belonging to this Institution, now deposited in the Museum of the Natural History Society, show that further to the West, at Ryal, the rock-surface, where it can be examined, bears the strongest evidences of glaciation. These specimens, which are ground down perfectly flat, are reported to have been obtained from a tunnel, the rock-surface of which was covered with 60 feet of superficial deposits. Under this deposit, the rock-surface was, when examined, as level as a slab of polished marble.

PHYSICAL FEATURES.

Many of the physical features of these counties must have struck most observers with their peculiarities. The Magnesian-limestone plateau with its ancient terrace lines; its rounded hills, sometimes almost conical; its valleys of denudation, *hopes*, as they are called; its own peculiar surface-drainage, in the form of deep secluded denes; its abrupt, irregular escarpment, stretching to the south-west, through the county of Durham, and forming one side of the ancient glacier valley through which flows the Wear; all these features must have been noticed by most observers. And, standing on the edge of this elevated, limestone escarpment, and looking across this broad Wear valley to the elongated, swelling, elevated sandstone ridges to the West; ridges due to the harder material of which they are composed, who can fail to observe the generally flat appearance of the upper Coal-measures deeply denuded, and broken only by those long swelling ridges of sandstone.

The Millstone-grit rears itself as a huge barrier when in its most characteristic form, and crowns the summits of the highest hills. The Mountain-limestone district, traversed only by few, has its own peculiar features. These have more the character of Alpine valleys and miniature river-basins. Standing on any of the heights of this elevated district, it does not require much reflection or comparison to comprehend the agencies that formerly were busily at work excavating the present river channels, and converting the excavated materials for future use, and carrying them onwards into the plains below. The similarity of the heads of some of these valleys to those of more mountainous districts cannot be overlooked, and there can, we think, be little doubt that the agencies by which they have been scooped out have been identically the same.

ARCTIC CLIMATAL CONDITIONS.

The phenomena presented to view in countries still under the process of glaciation, and more especially those districts of North America so long visited by our own intrepid seamen in search of a N.W. passage, Greenland, Iceland, Spitzbergen, and the Scandinavian peninsula, are best fitted for comparison with our own country, being more congenially situated, and more on a level with the sea. Elevated Alpine districts in lower latitudes, though presenting similar phenomena, are scarcely so eligible for comparison with a country so flat as our own, and situated also in a much higher latitude, as they represent only the extreme end of river valleys, and do not, now at least, protrude themselves into the lower grounds of the country and never reach the sea-coast; also, they pass over steeper inclinations, and the glaciation is limited to the sides of the glacier valleys. The reverse of this is the case in the Arctic regions, where many of the larger glaciers discharge themselves into the sea, and the inclination of their channels is very trifling compared with those of more southern mountainous districts. Also, the accumulations of snow are so great that the slopes and elevated ridges of land that border the valleys are covered more or less with thick accumulations of ice or half-melted frozen snow, forming enormous masses of land- or continental-ice, which move forward towards the valleys or sea-coast, and glaciate the rock-surface over which they move.

Most of the moisture that falls from the atmosphere in the Arctic regions, whether in summer or winter, is in the form of snow. In the latter season, so abundantly is this material deposited that the whole surface of the country, inlets, bays, and seas, are concealed under it. With the change of the season, and especially on slopes exposed more directly to the sun's rays, this covering gradually disappears. When entirely thawed, it is drained off over the rock-covered surface of the country, or it is only partially thawed, and then, in the form of *névé,* or in plain English, "sludge," it subsides into the hollows and depressions of the surface, to be afterwards more solidly frozen. On the more elevated ridges, and in the higher depressions of the land, this half frozen snow or *névé* accumulates year after year, and by its increasing weight a pressure is formed towards the lower parts of the country, and any lower surface on the boundary of this accumulated half-frozen mass eventually becomes, by accumulated pressure from the higher portion, the natural outlet or channel for the accumulated mass. In this manner, by increased pressure from accumulation above, the partially frozen mass gradually extends itself forward. It removes, according to its power, any resistance from the rock-surface it may meet with, widening or expanding itself where any broad depression occurs in its course. It fills up enclosed valleys, and gradually rising up above the level of their boundary, seeks for itself a new outlet, and pushes its icy mass forward and onward until it reaches the sea-coast, where enormous masses—the accumulations of centuries—are urged forward into the sea, forming perpendicular cliffs of ice, until the depth of water is sufficient to float them away into a new mode of existence. During the slow motion of this gradually-increasing mass of moving ice from the higher districts to the shore, it has not only lost much of its original composition, from the gradual wasting of its under- and upper-surfaces during periodical changes of temperature, but it has also been much increased in its progress by incorporating into its mass much of the annual deposits of snow. It has also been burdening itself with mud and rubbish, and enormous fragments of rock, which are annually loosened from its boundaries and discharged on to its surface by the powerful agencies of cold and heat, or frost and thaw. These rocky fragments, strewed over its surface and embedded into its sides, or deposited in some instances as long lines of rubbish, extending along its entire length, together with the sand and gravel deposited on the sides of its bed, give to the glacier its power to wear away and enlarge, and also to polish, scratch, and score the surface of the channel over which it passes. And not only the rocks *in sitû* are thus marked, but the fragmentary materials embedded into the icy stream are ground and polished and striated in a similar manner. It is unnecessary to suppose that the channel or bed of a glacier must be much sloped or inclined, or that a glacier valley must be perfectly level; like running water, if it meets with obstructions, it accumulates till it rises above or overpowers them, and likewise it does not hesitate to throw itself over a precipice or down a steep inclination, if such should come in its way. But the glaciers of Polar regions are, from their longer course and excessive thickness, generally less precipitous than those of Alpine districts, and preserve the even tenour of their way from the mountains which gave them birth to the sea, into which eventually they are launched, and in which finally they disappear. But in Arctic lands, not only are most of the lower valleys, glacier channels, but much of the flat country becomes covered with accumulations of continental-ice or coast-glacier, which are gradually pressed downwards, either to glacial valleys, when it becomes incorporated with it partially, or to the sea coast, where it is precipitated over the headlands on to the coast-ice below: such masses of ice carry with them detached rocky fragments, and by their aid polish and striate the surface over which they pass. There is always a strong current of water flowing underneath the glacier, which periodically increases in quantity, and which on such occasions is generally very muddy and turbid. The melting of the snow on the surface of the glacier also forms another system of waste and drainage. Most glaciers are crevassed or fissured transversely, either from compression of its mass within narrow limits, or by its passage over an uneven surface, or, when pushed into the sea, by the rapid erosion of its under surface. There are many other interesting details connected with the movements of glaciers, but the above particulars serve, perhaps, to illustrate the kind of agency by which our district has been formerly glaciated, and the manner in which the striated and polished boulders have been formed, and also the mode in which the materials forming our boulder-clay have been produced.

FORMER ELEVATION, AND SUBSIDENCE OF LAND.

It was stated before that the depth of the superficial deposits at the mouth of the Tyne are of unknown thickness; but there are a few sections up the Tyne valley, which, by showing the thickness of this deposit, also indicate that the land was formerly much higher than at present. In the "Wash" paper, the authors state that at the mouth of the Team valley the thickness of the deposit was 140 feet below the present high water level. There is an old section of the Percy-Main Engine Pit, nearer the present mouth of the Tyne valley, dated 1800, in which the superficial deposits, consisting chiefly of boulder-clay, are estimated at 183 feet. This fact and proof of the former elevation of the land being much higher than at present, is important, for it is necessary, in order to account for the deposition of the boulder-clay, and the beds of clay, sand, and gravel which occur all over these counties, to assume that the whole, or nearly so, of the entire island was submerged beneath the sea. It was during this period of submergence that the boulder-clay, which we have so many opportunities of inspecting, was deposited. We also infer that it was during the period of submergence that portions of the glacier of the Wear valley overlapping, or breaking through its time-honoured boundary, sought a shorter course to the sea through those numerous valleys of denudation which we see along the Magnesian-limestone escarpment. Can we doubt, when we look at the surface of this county from any considerable eminence, that the numerous isolated hills formed, at this period, numerous small islands, which were in their turn submerged, and covered with deposits still brought down from the west on floating masses of ice detached from the glacier face of the upper valley? Only one or two points along the whole extent of the Pennine range seem to have been exempted from this submergence,—Cheviot, perhaps, and the much-terraced Crossfell, higher than Cheviot, and two or three points further to the south. Should anyone question the fact of this submergence, we ask how were the large blocks of Shap granite brought across the Pennine range into the valley of the Tees? The block in the North Street, Darlington, being one of these. How does it happen that we have Criffle granite distributed among the most superficial deposits of the valley of the Tyne and the Wear? It is impossible to answer these questions satisfactorily, unless we admit the subsidence of nearly the whole of the Pennine range.

If the subsidence be admitted, as we think it must be, the reëlevation is evident; but, during this reëlevation, extensive modification of the formerly submerged surface, must have taken place. Enough observations have not yet been made to determine anything about the mode, whether by a gradual rise or by saltations, in which this reëlevation took place. In our own neighbourhood, and chiefly in the Magnesian-limestone district, the best indications of raised beaches—formed, probably, during this reëlevation—have been observed, and one of these has been particularly described. It was probably during this change that extensive floods, bearing rocky materials, washing through the valleys of denudation, spread the south-eastern parts of Durham with moraine-rubble and sand. During this time, also, excessive denudations of the boulder-clay would disengage the materials contained in it, and re-deposit them in the form of gravel, brick-clay, laminated-clay, and sand, of which such remarkable examples occur in the Wear valley.

CLIMATAL-CHANGE.

A word must be said on the change of climatal conditions which this theory involves. Let it be remembered that the British Islands are situated between the 50th and 60th degrees of N. lat.; that Cape Farewell, in Greenland, is in the same latitude as the Shetland Islands, and that Newcastle is in the same latitude as that part of Labrador which is permanently frozen two feet below the surface in summer; and that icebergs, in the spring, drift on the American coast further south than the latitude of the English Channel; and that at present all the Arctic drift ice passes to the South on the West side of the Atlantic. If we bear these facts in mind, I think the explanation of a change in the Oceanic currents the most feasible and probable one than can be offered, especially when we see that by its instrumentality the isothermal line of

South Labrador in the latitude of Newcastle is carried to South Greenland, North of Iceland and Lapland. That we are not entirely quit of Arctic currents and Arctic influences, seems to be indicated by the presence on the coasts of the North Sea of so many Northern forms of animal and vegetable life, and the bitter life-destroying air-currents of our spring months is a most unwelcome proof of our nearness to Arctic regions and Arctic influences.

CONCLUSION.

In order then, satisfactorily to account for the formation of such extensive valleys as those ancient ones of the Tyne, Wear, and Tees: to explain the abrasion, rounding and terracing of the sides of these valleys, and the polishing and scoring described in that of the "Wash"; and the polishing and striation of the rock-surface already observed in so many parts of these counties, it is necessary to call in aid the existence of such a climate and such physical conditions as exist now in Greenland, Spitzbergen, and other Arctic regions. It is necessary also, in order to account for the carriage of so many large blocks of Mountain-limestone and Millstone-grit, from the higher land, extending from the monoclinal ridge of the Pennine chain to the coast, to assume an agent, similar to a glacier accumulating in its early course, masses of rock and deposits of mud, derived from the rocky boundary of its channel, and bearing these onwards to the coast-line; and then, as the face of the glacier breaks off and floats out as an iceberg to sea, depositing its burden of rock and mud at different distances from the axis of distribution, or highest portion of the glacier valley. The theory of stranded icebergs, and masses of floating ice drifting along the coast-line, is quite insufficient and entirely inadequate to produce the appearances above enumerated, for it is pretty clear that these rocks were glaciated and covered over with a thick deposit of boulder-clay before the land was submerged deep enough for icebergs to pass over them. Stranded ice would, even on exposed rock-surface, be insufficient to wear and rub them down in the manner observed in these counties; in short, the effects produced by the stranding of an iceberg, are at present, merely conjectural, as no one has yet pretended to point out any special glaciations, produced by such an agent. And, if these bergs came from distant northern shores, they certainly ought to have brought as burden, rocks peculiar to the country they were formed on, but, we have seen that the transported materials embedded in the boulder-clay, are all of local valley origin: that is, they have been brought down the valleys of the Tyne or Wear, or some of the tributaries of these rivers.

Further, it is necessary, in order to account for the deposition of the boulder-clay not only along the valley-channels but on the tops of some of the hills, to infer a gradual subsidence with the last glaciation of the surface. The distribution of Criffle granite in the most superficial deposits of the Tyne valley, and the occurrence of massive blocks of Shap-fell granite along the course of the Tees, supports this inference.

The great depth of the old valleys below the present level of the sea certainly proves the former higher elevation of the land.

And with regard to climatal change, from Arctic to more temperate conditions, this inference is supported not only by the former prevalence of a more Arctic marine-fauna, but by the occurrence in these islands of fossil remains of the mammalia peculiar to the Arctic regions of the present period.

The best proofs and illustrations of this theory of glaciation by continental- or land-ice can be obtained by a careful perusal and study of the works of most of the Arctic navigators, especially of the "Arctic Explorations" of Dr. Kane.

found—gradually rise in a western direction, with an inclination exceeding that of the general rise of the country, until they bassett or crop out at the surface over a wide range of country, attaining their highest elevation at the mountain of Cross Fell, in Cumberland, and other adjacent fells or mountainous moorlands, which extend in a north or south direction, and form the western limit of the Lead Mining Districts.

The series of strata which extends between the outcrop of the lowest of the coal strata and the Cross Fell ridge of mountains is well known in the district as the Carboniferous, or Mountain-limestone formation—so called from the abundance of coal associated therewith, and from the numerous beds of limestone which prevail. These lead mining strata lie nearly midway in the series of formations which are found generally throughout England, being as much below the Tertiary beds of the South-east part of the island as they are above the Silurian rocks on the borders of Wales.

A lofty range of elevated land extends from the borders of Scotland to Derbyshire, occupying from twenty to thirty miles in width of the middle portion of the North of England. In many parts of this range of hills are extensive lead mines, which may be classed under the following districts :—

1st. Mining districts connected with the River TYNE and its tributaries, the NENT, East and West ALLEN and the DERWENT, viz.,

ALSTON MOOR, in the county of Cumberland.

East and West ALLENDALE, in the county of Northumberland.

BLANCHLAND and DERWENT Mines, in the same county.

In addition to these, which are distinct mining territories of considerable extent, other valuable lead mines in detached places have been discovered, some of which are extensively worked in the valley of the Tyne.

2nd. The extensive mining district of WEARDALE, occupying all the upper part of the valley of the River Wear, and its tributary valleys of Burnhope, Killhope, Wellhope, Ireshope, Rookhope, &c.

3rd. Another extensive district in and adjoining TEESDALE, the mines being situated chiefly in the valley of the River Tees and adjacent portions of Yorkshire and Westmoreland.

The geographical position of these districts may be readily understood by assigning to the upper part of the Rivers Tyne, Allen, Wear, and Tees, an area extending about twenty miles from their respective sources, and in the Derwent a range of about ten miles from its source. The area thus indicated comprises the principal lead mining districts of the North of England.

In any view of the history of mining, it is impossible to overlook its connection with geological conditions on which the very existence of the mines depends. The mind is thus carried back to a remoteness of time, for which an adequate expression has not yet been defined. The deposition of regularly stratified rocks over a large area of country exhibits proofs of gradual progress extending over enormous periods of time. Midway in this vast period we find in certain parts of the North of England evidences of volcanic action which has interposed basalt among the strata of sandstone, shale, and limestone. The results of this protrusion not only affect the subterranean operations in mines, but they also appear prominently at the surface, and give rise to some remarkable features of the scenery. The "Whin Sill," as it is locally termed, interrupts the gradual flow of the River Tees by a barrier over which that river falls at High Force, near Middleton-in-Teesdale, and it is the cause of the romantic cataract called the Cauldron Snout, near the source of that river. Precipitous cliffs of basalt, near Holwick, were formerly connected by a chain-bridge, one of the first, if not the earliest, of that construction in Europe. The same overflowing of basalt which occasions these and other striking features of landscape scenery in Teesdale, extends in a northeastern direction, and occasionally forces itself on the attention by the manner in which it seems to have invited the erection of works of art. This rock by its greater hardness, having withstood the abrading action which wore away the softer rocks, presents a firm foundation for buildings designed to be as strong as possible. Thus, for a considerable distance along the line of the Roman Wall, we find the direct course from Chesters to near Haltwhistle forsaken, and the wall built in a somewhat semicircular line to the North on the summit of precipitous crags of basalt. The pleasure grounds of the Duke of Northumberland at Ratcheugh, near Alnwick, afford an example of the protrusion of this rock. Dunstanborough Castle, Bamborough Castle, and Holy Island Castle may be mentioned as resting on basalt. But the underground occurrence of this rock concerns still more nearly the practical operations of the miner, and occasionally involves much costly labour by reason of its extreme hardness.

Old writers on mines and mining were seldom content to rest with a less remote antiquity than Creation itself, and it curiously marks the state of geological science even so late as 1670, when Sir John Pettus wrote his "History, Laws, and Places of the chief Mines and Mineral Works in England, Wales, and the English Pale in Ireland," that he speaks of the hills and dales as having been watery billows, formed by the breath of the Almighty into hills and valleys, which, says the writer, "have ever continued in these wonderful and pleasant dimensions." The same quaint writer speaks of Adam not only as a miner, but also as a refiner, etc., and nothing, he adds, "shows wisdom more than the getting of gold by proper courses." The allusions made by him and other early writers, to the getting of gold, and the minute directions which they give for the washing of gold, found on the surface, warrants a belief that this precious metal was formerly prevalent on the surface. It is by no means unlikely that its abundance was one of the attractions which led to the peopling of the island by strangers. Britain was probably in ancient times to Rome and other nations what California and Australia are in our day. Certain it is that gold and silver have from early times been specially reserved by the Crown, and some remains of this legislation are still apparent in the laws relating to these metals when found on or under the surface of the earth.

Owing to many circumstances Alston Moor was for long popularly known as a lead-mining district. Its mines have been for a long time, and yet are, open to public enterprise, and it forms a good type of the general condition of the lead-mining districts. Of its early history little is known. Its occupation by the Romans is attested by the extent and perfect preservation of some considerable works; and the position of the mineral veins in it and the adjacent districts is such as to render it almost impossible that lead veins were undiscovered during the time of the Roman occupation. The formation of the great military road called the Maiden Way must have exposed to view the mineralogical character of the rocks over which it passed, and the lead found in the Roman station at Whitley was most probably obtained from the immediate vicinity. Traces of ancient smelting places exist, as may be inferred from the scoriæ yet to be found, but of any detailed operations or exact localities there are not, that I am aware of, any records. It is not until about six centuries ago that any light appears by which to judge of the state of the mining districts; and even then, and for some centuries after, few and far between, and vague and ill-defined are the indications of the progress of lead-mining. The insecurity of property at that time, and the more especial uncertainties of Border property—for even then the Kingdom of Scotland included Cumberland, although the mining rights were claimed by the English Crown—may in some measure account for this. In the time of Henry IV. a lead mine is mentioned as having been worked in Essex, and Sir John Pettus enumerates the following counties as producing lead ore containing silver, viz.:—Devonshire, Gloucestershire, Worcestershire, Staffordshire, Leicestershire, Cheshire, Derbyshire, Lancashire, Cumberland, Northumberland, Yorkshire, the Bishopric of Durham, Flintshire, Denbighshire, Shropshire, Caernarvonshire, Merioneth, Montgomery, Carmarthen, Brecknock, Monmouth, Buckinghamshire, and Dorsetshire. From this it may be seen, that over a long period lead-mining operations were extensively spread over great part of England and Wales, whilst in Scotland the chief works were chiefly confined to Leadhills, a place where gold was formerly obtained in some abundance.

In Sir John Pettus' definition of poor mines and rich mines, or "Mines Royal," he states that where the ore digged from any mine doth not yield, according to the rules of art, so much gold or silver as that the value thereof doth exceed the cost of refining and loss of the baser metal wherein it is contained, or from whence it is extracted, then it is called poor ore or a poor mine.

On the contrary, where the ore digged from any mine doth yield according to the rules of art, so much gold or silver as that the value thereof exceed the charges of refining and loss of the baser metal in which it is contained and from which it is extracted, then it is called rich ore, or a "Mine Royal," and it is appertaining to the King by his prerogative. In this we have the definition of the limits within which it appears the mines of Alston were included as Mines Royal, and the importance of which is prominently marked in the several charters which the Kings of England in successive reigns conferred by virtue of that prerogative.

Sir J. Pettus states that the mines in Devonshire, Somersetshire, and Cornwall were wrought by the Romans, who, in the period of three or four hundred years that they occupied the mining districts of the North of England, doubtless exercised their knowledge of the art, and Cæsar expressly mentions, that one reason of his invading the Britons was, because they assisted the Gauls with the treasures with which their country abounded. It appears moreover that in these times, and long after, the practice was to condemn to the mines those who had committed any heinous offence against the laws of the land.

In the beginning of the fourteenth century (1304) mention is made of indemnities granted to miners in Cornwall, and of liberty to turn water courses for their works at pleasure. Thirty years later certain mines, in which gold was found in lead ore, are mentioned in Shropshire. "A concealed mine of gold" is referred to (1401) in a letter of Mandamus; and in 1426, Henry VI. granted to John Duke of Bedford "all mines of gold and silver within his kingdom of England for 10 years, paying the tenth part to the Holy Church, to the king the fifteenth, and to the lord of the soil the twentieth part. In 1438 the same King granted to John Sollers all mines of gold and silver in Devon and Cornwall, and all mines of lead holding silver and gold, to hold (from the expiration of twelve years formerly granted to the Duke of Bedford) for twenty years, paying the fifteenth part of pure gold and pure silver. In 1451 the same King made his chaplain, John Boltwright, comptroller of all his mines of gold and silver, copper, lead, etc., within the counties of Devon and Cornwall; and in the following year the same Boltwright is mentioned as "provost and governor of all his mines," and a grant was made to him of all mines of copper, tin, and lead in Devon and Cornwall, to hold during his good behaviour, paying the tenth part of pure gold and silver, copper, tin, and lead, with power to let and set for twelve years, paying to the King the tenth bowl of ore, etc., holding gold or silver, and to dig without interruption, etc.

These notices, some of them referring to mines generally, and others only as contained in certain counties, are curious, as showing the manner of the Crown's disposal of them. The constant mention of gold and silver is quite different to any mining conditions of modern times, and the limited periods of 10 or 12 or 20 years would seem to imply that no large works were contemplated—the continued security for a long period, under which alone extensive and deep mines can now be worked, not being required in virgin mines, in times when the implements and machinery were adapted only for carrying on operations to an inconsiderable depth.

In 1468, Edward IV. granted to Richard Earl of Warwick, John Earl of Northumberland, and others, all mines of gold and silver, etc., on the north side of Trent within England, and all mines of lead holding gold or silver in the same parts, for 40 years, paying to the King the twelfth part of pure gold and silver, and to the lord of the soil a sixteenth part, with liberty to dig, except under houses and castles, without licence.

In 1475, the same King granted to Richard Duke of Gloucester, Henry Earl of Northumberland, and others, the mines of Blanchland, called Shildon, in the county of Northumberland, and the mine of Alston Moor, called Fletchers; the mine of Keswick, in Cumberland, and the copper mine, near Richmond, to hold the same for 15 years, paying to the King the eighth part, to the lord of the soil the ninth part, and to the curate of the place a tenth part, as they arise.

In 1478, the same King granted (on surrender of the former grants) to William Goderswick and Doderick Vaverswick all mines of gold, silver, copper, and lead in Northumberland and Westmorland, to hold the same for 10 years, paying to the King a fifteenth part, and to the lord of the soil and to the curate as they can agree.

In 1486, Henry VII., by his letters patent, dated February 27th, made Jasper Duke of Bedford, and other earls, lords, and knights, *Commissioners and Governors* (a designation retained until very lately in the direction of the estates of Greenwich Hospital) of all his mines of gold, silver, tin, lead, and copper in England and Wales, to answer the profits to the King, and made Sir William Taylor comptroller, to hold the same for 20 years, with liberties of court and other privileges, paying to the King the fifteenth part of pure gold and silver, and to the lord of the soil the eleventh part as it grows.

For a period of about 50 years following the appointment of this commissioner in the reign of Henry VII., little of moment appears to have been done; and in the third year of the reign of Queen Elizabeth a society was appointed, entitled the Society for the Mines Royal, to whom a grant of gold, silver, and copper was given within the counties of York, Lancaster, Cumberland, Westmorland, Cornwall, Devon, Gloucester, and Worcester, as also in Wales, with liberty to grant and assign parts and portions. The various laws and regulations of this and similar societies do not throw any light on the local details of mining, and the general rate of duties and conditions of the North of England lead mines in the above periods, can only be inferred from the probability of their having been included in some of the grants already recited.

In other lead-mining districts we find more minute details of local customs; such, for example, are the laws of the lead mines of Derbyshire, and Mendip, in Somersetshire; but I find no trace of any of these peculiar customs having prevailed in Alston, or the adjacent districts in the North of England. One of the Derbyshire customs or regulations is curious enough—"If any blood be shed upon the mine, the author shall pay 5s. 4d. the same day, or else shall double the same every day till it come to 100s. 5s. 4d. was also the apparently moderate penalty in case of underground trespass. The laws and customs are described as being those of the mine used in the highest peak, and in all other places through England and Wales." The miners sued that the King "would confirm them by charter under his great seal, by way of charity and for his profit, forasmuch as the aforesaid miners be at all times in peril of their death, and that they have nothing in certain but that which God of his grace will send them."

The information to be thus gleaned is scanty enough, and admits not of being woven into a connected narrative; yet it indicates the scale of payment to the several parties concerned—the shortness of the term for which grants were made—the absolute right of the Crown, and the participation of a portion of the revenues by the Church. The miners of Alderston or Alston had royal protection granted them in 1233, again in 1236, and again in 1237. In 1282, the manor of Alderston was granted by Edward I. to hold in fee of the King of Scotland, reserving to himself and to the miners various privileges, especially such as belonged to the franchise of Tindale, within which Alston was then comprised.

The details of grants and charters more immediately relating to Alston appear to correspond, in general terms, with those more general grants which I have specified as elucidating the early progress of mining in this kingdom generally. In 1333, several of the privileges above alluded to were confirmed to Robert, son of Nicholas de Veteripont, and in the following year some further liberties were confirmed, from which it appears that Alston at that period had not only mines but a mint.

The ancient names of park and forests which occur in these Northern mining districts as applied to extensive tracts of land are worthy of mention, as they show in a striking manner the abundance of forest timber which once adorned the now nearly treeless districts under consideration. In 1290, Patric of the Gill, and 26 other miners, were empleaded by Henry de Whitby and Joan his wife for cutting down their trees at Aldeneston by force and arms, and carrying them away to the value of £40. The miners claimed that they held the mine of the King, and were privileged to cut wood. The context sufficiently indicates that there had in former times existed vast quantities of wood; that it was extensively used for the mines; that the country was thus rendered bare and treeless; in which state only too much of it yet remains.

Another intimation contained in these ancient records leads to the supposition that mining cases were, at one time, subject to the decision of juries of miners, similar to those which existed in other parts of the kingdom, and such as I have had occasion to investigate more closely in connection with the Forest of Dean.

Alston Moor afterwards became the property of the Hyltons of Hylton Castle, in the county of Durham, and a lease was ganted in 1611, for 999 years, by Henry Hylton, subject to the payment of certain rents which amount to £64. In 1629, the manor was sold to Sir Edward Radcliffe for £2500, and it remained the property of that family till the confiscation of the estates of James Earl of Derwentwater, in 1716. It was granted by the Crown, in 1734, to the Royal Hospital for Seamen at Greenwich, and has ever since remained in the possession of the Commissioners in trust for that institution. Adjoining estates have subsequently been purchased and added to the original tracts of land so given.

It would be a work of some labour to extend these notices to the details of property and succession in the several other districts. The only practical result would be to discover a period when general and undefined royal rights were gradually brought into narrower compass by increasing enterprise in private adventures, and when mining was doubtless encouraged by liberal immunities. It would be difficult to pursue, in any minuteness, the gradual advance of improvement and of distinct rights of property over clearly defined districts. The royalties of Allendale passed into possession of the Fenwicks of Wallington, of the Blacketts, and eventually of the family of the present possessor Wentworth Blackett Beaumont, Esq., M.P. The Weardale mines are held under lease by the same owner from the Ecclesiastical Commissioners. The mines in Teesdale belong to various lords, of whom the Duke of Cleveland is the chief; and at and near Blanchland, in the valley of the Derwent, the royalties belong to H. Silvertop, Esq., and other proprietors. It is interesting to endeavour to mark some points at which the former vague and uncertain processes of mining in these lead districts were replaced by more exact methods, and I apprehend that such a period of change may be distinctly traced in the supervision of the great engineer Mr. Smeaton, who was for some time agent of the Greenwich Hospital estates in this district. It is certain that one great work which he projected, and commenced at Alston in 1775, gave a new and important stimulus to mining. This was the Nent Force Level; a work of great magnitude and vigorous conception, well adapted to the then existing state of information and to the imperfect state of engines for exerting great power. About the same period the progress of mining in Allendale owed much to the ingenuity of Mr. William Westgarth, who first introduced water-pressure engines. The generous interest taken by Smeaton in the promotion of so useful a discovery, may be seen by his communications to the Society of Arts. Details of the construction of Mr. Westgarth's engine appear in the early volumes of the Transactions of that society.

"The old man" is the local phrase by which ancient mining operations in these districts are described. The greater or less abundance of produce of lead was scarcely matter of public interest, nor were the fluctuations of price such as would have been felt as in the case of coal. Carried on in remote districts, which, until the present century, were almost inaccessible except on ponies, it is not surprising that few details of local history of an authentic and detailed character exist. We find only meagre traces of the events of a secluded district, and of a people shut out in a great measure by their occupation, even from the few dwellers on the surface of their own remote dales.

The earliest method of working lead mines appears to have been by shafts, and by following the surface indications of ore downwards. The driving of levels for drainage in Dean Forest was of later origin, and probably so in the other mining districts of the kingdom. The work was drawn to the surface in kibbles or small tubs, and some of the smaller pits on the bassett of inferior beds of coal yet present, what probably was, the appearance of a respectable mine in the infancy of such operations. The general use of levels or galleries large enough to admit horses travelling in them, is said to have been introduced into the lead-mining districts, by Sir Walter Calverly Blackett, about 120 years ago; but the example was not, as I believe, followed for many years by other mine owners. Cast iron rails, instead of wood, were first used in Nent Force Level. Tin pipes were first used for ventilation by Low, Carlisle and Co., at Tyne bottom mine. Mr. Stagg, manager of the mines belonging to the London Lead Company, for many years, introduced iron pipes at Rampgill, and Mr. Dickinson, moor master of the Alston Moor Mines in 1826, first used lead pipes for the purpose of ventilation in the Nent Force Level. Any of these materials were an improvement on the wooden boxes, which rapidly decayed, and so rendered the air impure, and which, moreover, could with difficulty be kept water-tight. I may take occasion here to mention, that for a period of about half a century, the extensive mines of Allendale were under the management of members of the family of

Mr. T. Crawhall, and more especially of his sons, Messrs. George and William Crawhall, whose active and useful labours were only terminated by the infirmities of age, which induced them to retire. The influence which they exercised during so long a period in prosecuting some of the most extensive and prosperous lead mines which have ever been worked in this kingdom, is well worthy of notice in any account of the progress of mining in the lead districts of the North of England. I may also advert to the introduction of the crushing mill, of the German Buddle, and of the addition of inclined flues or chimneys to carry off smoke from the smelt mills. These flues, chiefly erected during the agency of the Messrs. Crawhall, are built of masonry, eight feet in height, and six feet in width. The aggregate length of the flues connected with the mills belonging to Mr. Beaumont, is nearly nine miles.

Another important improvement, effected under the management of these gentlemen and by the owners of other lead mining districts, was the introduction, about forty years ago, of good turnpike roads by which the whole of Alston, Allendale, Weardale, and Teesdale may now be traversed; the excellence of such communications requires no stronger comment than an inspection of the remains of old roads, which, in many cases, consisted of mere heaps of broken rocks, climbing the exceedingly steep hills and plunging into deep valleys. The turnpike roads which have superseded them are of excellent construction.

One of the most valuable and interesting improvements relating to lead mining and its processes, was made in the method of separating silver from lead by the late Hugh Lee Pattinson, Esq. This process which has justly received the highest commendation, and which, indeed, carries with it intrinsic evidence of the manner in which science may be employed to give new interest, and new value to the practice of the useful arts. Explanatory details of this process may be seen in the galleries of the Museum of Practical Geology in London. The process itself, on a large scale, may be witnessed in many of the principal smelting works of the Kingdom, and Mr. Beaumont, in his invitation to the members of the British Association, at Newcastle in 1863, offered a free inspection of it to all the visitors at his smelting mills.

In 1838, Mr. Pattinson communicated to the British Association a full account of his discovery, as constituting a new process in the arts, and affording the means of a great saving of cost in the extraction of silver from lead. Previously to its introduction, the method of separation depended on the readiness with which lead at a red heat is converted into an oxide; whereas silver, at the same or a very much higher temperature, retains its liquid metallic state, and may be obtained in cakes of convenient size for the market. These are usually of the value of £400 or £500; but at the Exhibition, in London, of 1851, two cakes were exhibited, one by Mr. Pattinson, of about £2000 value, the other of £3000 value; the latter having been prepared at Allen Smelt Mill, at which place the discovery was originally matured by Mr. Pattinson.

At the meeting of the British Association, at Newcastle in 1838, the author of this paper exhibited various sections in detail, showing the arrangement of the stratified beds of rock which extend over the lead-mining districts of the North of England, and the published Report of the London Exhibition of 1851 contains an account of the several processes generally used in the extraction and preparation of the ores of lead. It would extend this paper beyond reasonable limits to recapitulate these details or to enter on separate descriptions of each particular mining field. The produce of each district of mines has been regularly recorded since 1845 in Mr. Hunt's Statistical Returns. I cannot close these observations without expressing a strong sense of the value of the records collected by Mr. Hunt, and repeating the opinion I have often expressed, that a correct and methodical system of keeping mining records is worthy of further attention, not only on the part of individual proprietors, but on the part of the Legislature, for the public benefit.

In conclusion, I may mention, as a prominent feature of lead-mining operations, the work called The Blackett Level, commenced by W. B. Beaumont, Esq., M.P., in his manorial property in East Allendale. The shafts on this work were commenced in 1855, and the adit level near Allendale Town was begun in 1859. The entire length, when completed, will be nearly seven miles. At three of the shafts, and also at the Allenheads mines, are several extensive adaptations of improved hydraulic engines, invented by Sir Wm. Armstrong, and particularly described by him at the last meeting of Mechanical Engineers held in this town.

The following table exhibits the several quantities of lead ore raised in the northern counties:—

PRODUCE OF LEAD IN THE YEARS 1845 TO 1862 INCLUSIVE, IN THE COUNTIES OF CUMBERLAND, DURHAM, AND NOTRHUMBERLAND.

Name of Mine.	1845. Tons.	1845. Cwts.	1846. Tons.	1846. Cwts.	1847. Tons.	1847. Cwts.	1848. Tons.	1848. Cwts.	1849. Tons.	1849. Cwts.	1850. Tons.	1850. Cwts.
Cumberland.												
Alston Moor Mines	4615	..	4330	..	1470	..	4320	..	4921	7	5155	11
Roughtingill	87	..	..	..	..	..	..	..	..	..	64	..
Driggith Beck Waste	10	..	2	..	24	..	15	..	..	..	..	..
Dry Gill Mine	..	..	6	..	8	..	27	..	30	..	1	..
Driggith Mine	37	..	18	..	..	..	..	..	..	..	75	8
Greenside	1100	..	1200	..	1200	..	1200	..	1300	..	1420	..
Keswick Mines	..	..	..	..	..	..	14	..	35	..	107	5
Tynehead Mines	..	..	..	..	..	..	96	..	41	..	27	..
Goldscope	..	..	..	..	..	..	..	..	..	..	..	..
Brandlehow	..	..	..	..	..	..	..	..	..	..	..	..
Sundries	12	..	..	..	..	..	12	..	..	..	..	..
Total	5861	..	5556	..	5702	..	5681	..	6327	7	6850	4
Durham and Northumberland.												
E. and W. Allendale and Weardale	8502	..	8372	..	9300	..	9080	..	9162	..	9801	..
Teesdale Mines	1688	..	1870	..	1870	..	2490	..	2576	..	3220	11
Derwent Mines	..	..	..	..	1033	..	1046	..	1001	..	1280	..
Stanhope Burn	..	..	..	..	..	..	160	..	..	..	280	8
Holly Well	..	..	..	..	..	..	48	..	51	..	582	..
Lane Head	..	..	..	..	..	..	17	..	8	5	18	..
Aller Gill	..	..	..	..	..	..	8	..	..	..	11	..
Bollihope	..	..	..	..	..	..	9	..	5	1	9	..
Fallowfield	..	..	..	..	..	..	45	..	88	..	120	..
Whitfield	..	..	..	..	..	..	105	..	54	..	19	..
Langley Barony	..	..	..	..	..	..	..	..	851	..	2	..
Settlingstones	..	..	..	..	..	..	..	..	260	..	375	..
Brandon Walls	..	..	..	..	..	..	..	..	..	..	79	..
Healyfield	..	..	..	..	..	..	..	..	..	..	..	..
Stone Croft	..	..	..	..	..	..	..	..	..	..	..	..
Flakerigg	..	..	..	..	..	..	..	..	..	..	..	..
Sundries	58	..	42	..	42	..	170	..	10	..	40	4
Total	10218	..	10284	..	12215	..	13178	..	14066	6	15810	8

Name of Mine.	1851. Tons.	1851. Cwts.	1852. Tons.	1852. Cwts.	1853. Tons.	1853. Cwts.	1854. Tons.	1854. Cwts.	1855. Tons.	1855. Cwts.	1856. Tons.	1856. Cwts.
Cumberland.												
Alston Moor Mines	4791	12	4210	15	3865	19	4914	6	4887	12	4377	12
Roughtingill	..	..	..	..	135	..	120	..	205	..	315	..
Driggith Beck Waste	..	..	..	..	..	..	..	..	..	..	..	..
Dry Gill Mine	..	..	..	..	..	..	..	..	..	..	..	..
Driggith Mine	..	..	..	..	160	..	195	..	120	..	165	..
Greenside	1120	..	1466	..	1156	..	1100	..	1100	..	Returns not received.	
Keswick Mines	73	10	137	..	63	..	33	10	96	..	..	..
Tynehead Mines	34	..	50	..	55	10	56	10	125	15	128	9
Goldscope	11	..	14	..	190	..	243	..	303	..	305	..
Brandlehow	..	..	..	..	..	..	..	..	92	10	..	..
Sundries	..	..	..	..	..	..	..	..	..	..	..	..
Total	6333	2	5877	15	5619	9	6662	6	6929	17	5321	1
Durham and Northumberland.												
E. and W. Allendale and Weardale	9977	..	10313	..	9901	..	9200	..	9031	..	9137	..
Teesdale Mines	3769	1	3146	..	2680	..	5013	16	4508	10	4755	..
Derwent Mines	1200	..	875	..	1000	..	800	..	1240	..	1350	..
Stanhope Burn	231	1	218	16	..	..	144	..	191	2	208	16
Holly Well	18	..	20	..	7	..	4	..	1	5	3	6
Lane Head	20	..	20	10	16	4	2	10	8	..	28	6
Aller Gill	6	10	1	18	..	..	..	..	..	..	6	..
Bollihope	7	..	22	..	8	..	3	..	13	2	18	..
Fallowfield	122	..	80	..	160	..	144	..	150	..	150	..
Whitfield	15	..	8	10	11	..	..	..	..	..	..	..
Langley Barony	..	..	..	..	..	..	..	..	..	..	..	..
Settlingstones	..	..	735	..	712	..	810	..	600	..	925	..
Brandon Walls	78	..	76	..	66	..	45	..	40	..	56	5
Healyfield	..	..	..	..	250	..	280	..	320	..	445	..
Stone Croft	..	..	..	..	62	..	125	..	165	..	290	..
Flakerigg	..	..	89	18	81	5	32	8	..	..	..	..
Sundries	45	..	71	19	83	16	50	10	44	..	1	18
Total	15188	12	15978	11	15041	5	16681	4	16309	19	17671	11

Name of Mine.	1857. Tons.	1857. Cwts.	1858. Tons.	1858. Cwts.	1859. Tons.	1859. Cwts.	1860. Tons.	1860. Cwts.	1861. Tons.	1861. Cwts.	1862. Tons.	1862. Cwts.
Cumberland.												
Alston Moor Mines	3831	16	4052	17	4051	9	3918	5	3645	10	4159	2
Roughtingill	296	..	253	..	221	..	263	..	223	12	211	4
Driggith Beck Waste	..	..	..	..	..	..	..	..	..	..	..	..
Dry Gill Mine	..	..	..	..	..	..	..	..	..	..	..	..
Driggith Mine	171	7	156	..	137	14	137	9	103	15	122	17
Greenside	Returns not received.				..	..	..	..	..	..	1000	..
Keswick Mines	..	..	..	..	..	..	178	..	..	..	80	5
Tynehead Mines	151	18	88	5	119	9	45	10	85	5	41	4
Goldscope	255	..	388	..	300	..	325	..	348	2	318	2
Brandlehow	..	..	230	..	..	..	222	..	225	4	212	12
Sundries	..	..	..	..	421	2	..	..	..	..	66	4
Total	4706	1	5168	2	5250	14	5119	4	4581	8	6241	10
Durham and Northumberland.												
E. and W. Allendale and Weardale	8974	..	8148	..	7659	..	6925	..	8120	..	8300	..
Teesdale Mines	4535	9	4645	19	3446	11	3863	16	3185	8	3639	4
Derwent Mines	1120	..	1106	..	1100	..	1010	..	1051	12	1011	..
Stanhope Burn	99	3	67	10	76	10	..	..	..	..	..	..
Holly Well	5	..	..	..	..	..	..	..	..	..	..	..
Lane Head	22	..	10	10	8	12	10	..	6	6	10	6
Aller Gill	2	10	..	8	..	..	..	..	..	..	..	..
Bollihope	16	17	124	..	213	..	235	10	188	2	30	..
Fallowfield	227	11	300	..	419	8	325	6	336	..	246	13
Whitfield	..	..	..	..	..	..	..	..	..	..	..	..
Langley Barony	..	..	39	13	68	4	11	4	33	7	65	14
Settlingstones	1350	..	1120	..	750	..	010	..	356	..	365	15
Brandon Walls	60	..	51	..	62	2	53	7	53	2	67	17
Healyfield	60	..	130	..	80	..	116	..	190	..	296	..
Stone Croft	465	1	480	..	1000	..	900	..	690	..	918	15
Flakerigg	..	..	285	..	..	..	753	12	723	12	810	..
Sundries	36	5	5	2	..	..	91	7	52	17	692	16
Total	16973	16	16816	2	14888	1	15208	2	15286	6	16454	..

The principal strata of the lead-mining districts are represented in the section, Plate XVI., at the commencement of this paper.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, SATURDAY, JUNE 4, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-ON-TYNE.

G. C. GREENWELL, Esq., in the Chair.

The Secretary having read the minutes of the Council Meetings proceeded to read a letter from the President, apologising for his absence, as he was unavoidably detained in London, also a letter, accompanying a pitman's shovel, was read from Mr. Berkley.

ON THE MAGNESIAN-LIMESTONE.

Mr. Daglish then gave an abstract of a paper on the Magnesian-limestone, the joint production of himself and Mr. G. B. Forster.

The Chairman said, Mr. Daglish had given a very succinct resumé of his paper under its different heads. Leaving the question as to whether the salt water found in the Magnesian-limestone was in connection with the sea, there was another thing to be noticed, that, besides the salt, the water contained other substances not found in the sea. Mr. Daglish had referred to Wallsend. He (the Chairman) had analysed some of the water found there, and though it contained chloride of sodium yet there was the additional element of chloride of calcium. This might lead to the question how the water passes through the limestone.

Mr. Dunn inquired to what cause the saltness was to be attributed?

Mr. Daglish—I think the water in Seaton Pit comes from the sea.

Mr. Dunn—You say it is salter than sea-water.

Mr. Daglish—No; the water which is salter is found in another part. The late Mr. T. J. Taylor thought that salt beds in some countries were formed by the evaporation of saline water, the salt being left behind.

Mr. Atkinson here remarked that the discussion was irregular; the paper was not yet open for discussion.

ON THE ANTHRACITE COAL OF AMERICA.

Mr. Green said he had no further remarks to offer on this subject.

The Chairman said the paper of Mr. Green gave rise to one or two remarks from himself, which were read at a previous meeting. These remarks were given with all deference and respect, but they appeared not to agree with Mr. Howse's notes on the subject. [The Chairman read some extracts from Mr. Taylor's work, and proceeded.] Mr. Howse had also told him that the country to which he had referred was not in the band to which Mr. Taylor referred, but was in a belt of rocks of newer formation nearer Philadelphia. What he (the Chairman) said must have arisen from what he had read in Mr. Taylor's book. He thought he could say that he now agreed with Mr. Green.

Mr. Green referred to a specimen which he had not brought with him, which belonged to the Old-red-sandstone formation, which underlies the Anthracite coal.

ON A WASH OR DRIFT THROUGH THE COAL-MEASURES OF DURHAM.

The authors of this paper, Mr. Wood and Mr. Boyd, were not present.

Mr. Green suggested that, as the authors of the Wash paper were not present, and the members had scarcely had time to read Mr. Howse's paper on Glacial Action, the discussion on these had better be adjourned.

Mr. Morison said, he had prepared some notes on the fact that no existing glaciers were on as level a slope as those referred to by Mr. Howse were supposed to have been. These notes, however, were only in a loose form, and were intended to have been brought out in the course of the discussion.

The discussion was adjourned.

ON THE EXTENSION OF THE COAL-MEASURES UNDER THE RED-SANDSTONE OF CUMBERLAND.

Mr. Dunn's paper on this subject stood next for discussion.

The Chairman said, the march of discovery led to the conclusion that, as a general rule, coal did extend under the Red-sandstone. It was so found in Lancashire, on the borders at least, and in Cheshire. But more particularly in Somersetshire and Gloucestershire, they found it existing as in any ordinary Coal-measure where there was no New-red-sandstone. As to the fact of its extension under the New-red-sandstone of Cumberland that must be established as the result of argument.

Mr. Atkinson said, he was not well up in this matter; but it struck him that there was a dispute whether this so-called Red-sandstone was the New-red-sandstone or the Old-red-sandstone.

Mr. Daglish said, that Sir Roderick Murchison and Professor Harkness had published, last month, some notices on the new red rocks on the opposite coast, and they mentioned incidentally that those below the coal in this district were not of the Lower New-red-sandstone series, but carboniferous rocks; this was the conclusion arrived at by Mr. Forster and himself.

Mr. Dunn, referring to the Red-sandstone which was traceable all the way from Whitehaven to Maryport, wished to know what was the geological term.

The Chairman said, that in coal drifts driven towards the west they met with what seemed to be a cutting off of the old strata. Did that show an indication of a down-throw fault. It was a very curious fact that in a great many cases where they had Red-sandstone towards the Coal-measures they had a large down-throw fault. They had a similar case to this in Cheshire. In the west working they came to what was called a brow. It had been cut through. This was identical with the outcrop of the New-red-sandstone at the surface. It was thought that with such a fault as threw down the strata to such an extent, if the Coal-measures were to be found at all they must be at an extraordinary depth. They had since put a drift through this fault and found coal beyond it.

The discussion on Mr. Bell's paper, "On the Manufacture of Iron," was postponed in consequence of the author not being present.

The Chairman said, he would now draw their attention to the list of Vice-Presidents and Council.

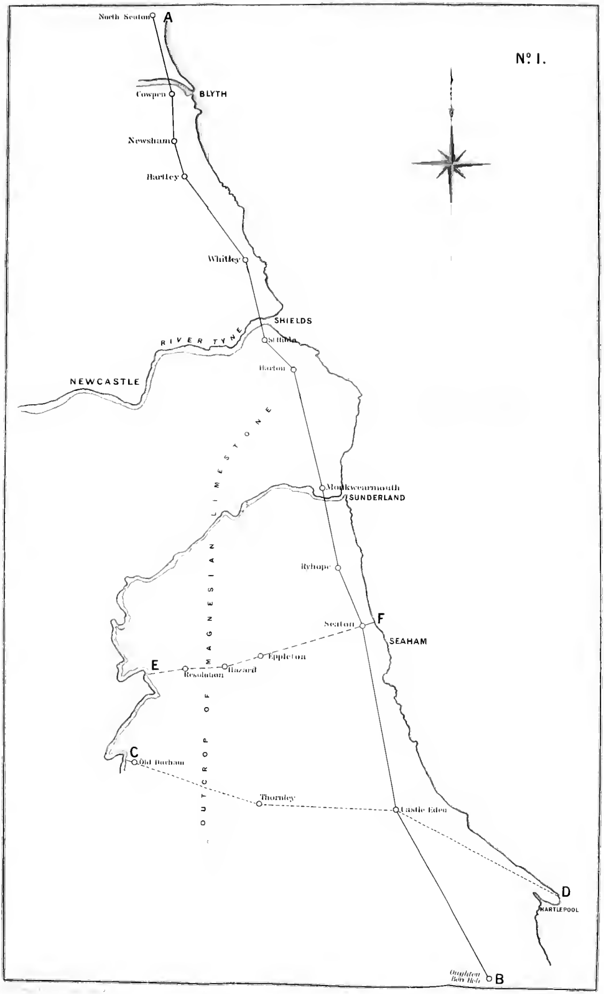
Mr. Daglish said, last year the election of officers came unawares on the members as at present. Unless they are nominated they cannot be elected. Last year some one nominated all the members.

Mr. Southern begged to nominate all the members for all the offices.

Mr. G. B. Forster seconded the motion, which was carried by show of hands.

Mr. ATKINSON said, he had a letter from M. Lambert, Mining-engineer of the Belgian Government, offering to exchange the Annals of Public Works of Belgium for the Transactions of the Institute. Two of the volumes of the Institute were out of print, and in case the exchange was made these ought to be excepted, unless they should be reprinted. He believed there were twenty-three or twenty-four volumes of the Annals of Public Works. Probably this would be a question for the Council to decide.

The meeting then adjourned.


No. I.
North Seaton
A
Cowpen
BLYTH
Newsham
Hartley
Whitley
SHIELDS
RIVER TYNE
NEWCASTLE
Harton
OUTCROP OF MAGNESIAN LIMESTONE
Monkwearmouth
SUNDERLAND
Ryhope
F
Seaton
SEAHAM
Eppleton
E
Resolution
Hazard
C
Old Durham
Thornley
Castle Eden
D
HARTLEPOOL
B

ON THE

MAGNESIAN LIMESTONE OF DURHAM.

By Messrs. JOHN DAGLISH, F.G.S., and G. B. FORSTER, M.A.

Covering, as it does so considerable a portion of the Northern Coal-field, the Magnesian-limestone must always afford a most interesting study to those engaged in the mining operations of this district. This arises from its important bearing not only on geological, but also on physical conditions; the former has long been a subject of general interest, and as regards the latter, one of the most marked features is the large quantity of water met with in the shafts which have been sunk through it for the purpose of winning the coal below. It was more especially to this feature that this paper was, in the first instance, proposed to be directed; but in the preparation of the required maps and sections, it was found that allusion to other debateable ground could not be avoided.

This deposit has, at various times, occupied the attention of some of our ablest geologists, and has been carefully investigated by them, so far as it can be seen in its sections open to the day; but the writers, in the pursuit of their professional duties, having had frequently brought before them sections of the entire deposit in the numerous coal-shafts which have passed through it, and having obtained the true inclination of the Coal-measures underlying a large tract of the Limestone in the workings of the various coal mines, have had suggested to them conclusions somewhat at variance with the opinions expressed by recent writers, and which they deem of sufficient interest to bring before this Association.

In all the sinkings through the Magnesian-limestone, feeders of water, more or less considerable, are met with at a certain distance from the surface, derived not so much by percolation through the mass of the rock—for this can obtain to a small extent only—but collected in and coming off the numerous gullets and fissures which everywhere intersect and divide the mass of strata. If the shaft be not drained by pumping, or otherwise, the water from these feeders rises to a point which remains, save in exceptional cases, constant. A line drawn between these various ascertained points gives the line of saturation, indicated by dotted lines, on the accompanying sections; and it will be observed, that although this line commences at the sea level, it neither continues on this plane nor follows the line of stratification, nor yet all the undulations of the surface, but rises for the most part uniformly with it as it passes inland. At Seaton Pit, near Seaham, it is 226 feet from the surface, and at Eppleton (Diagram No. 2), three miles directly West of Seaton, it is the same; and as the surface level of the latter is 180 feet above that of the former, it follows that the line of saturation rises in this direction at the rate of 60 feet per mile.

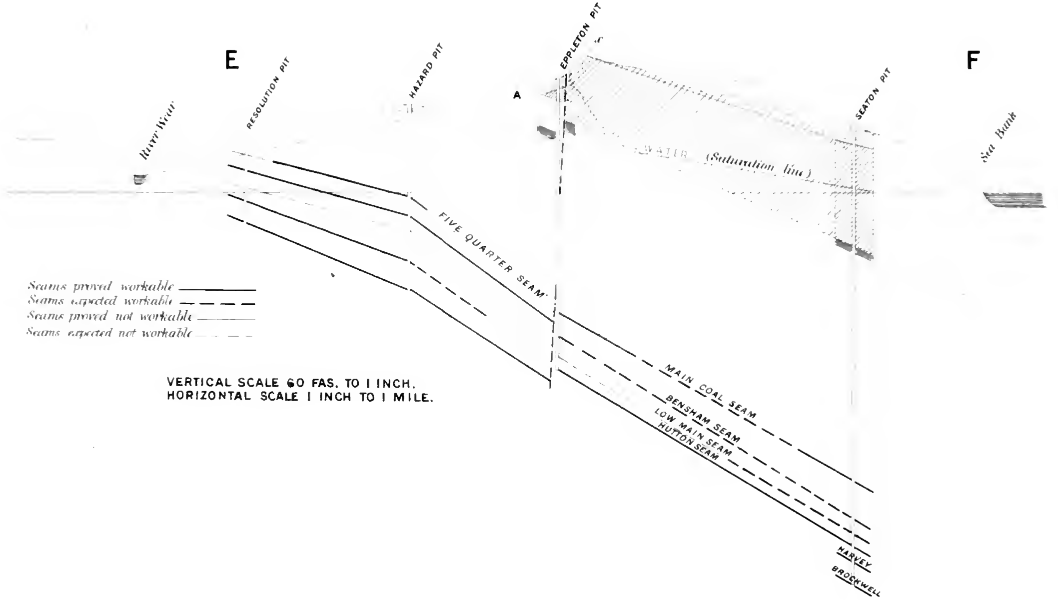
It was mentioned previously that under certain circumstances there is a slight variation in the level of the line of saturation; this occurs sometimes near the outcrop of the Limestone, when after a long succession of wet weather the level is raised a few feet; and again in some cases, where gullets are exposed on the surface, down which large quantities of water from flooded brooks, etc., find their way, and hence in any shaft communicating with these gullets the water rises rapidly and considerably.

Immediately underlying the Limestone is a bed of sandstone of very variable thickness, which when exposed to the action of the atmosphere disintegrates rapidly, and has hence acquired its local name of "friable Yellow-sandstone." It is in sinking through this bed of rapidly-decomposing sandstone that such great engineering difficulties have been encountered, owing to the enormous quantity of water which in some cases is met with, more especially if the bed be thick, and much below the level of saturation. A very full account of the sinking of the Murton Winning is given by Mr. Potter in Vol. V. of the Transactions of this Institute. In this case nearly 10,000 gallons of water per minute were pumped out of this bed by engines exceeding in the aggregate 1,500-horse power. The circumstances which favour the remarkable accumulation of water in the Limestone, and the rapidity with which it is drained off into pits sunk through it, is due to several causes—some of which are peculiar to this formation, and perhaps to this district. They are:—

1st. The arrangement of the beds of stratification.
2nd. The contour of the country.
3rd. The permeability of this formation to water.

On examining Diagram No. 2, it will be observed that the beds of

No. 2.


E
F
River Wear
Resolution Pit
Hazard Pit
Eppleton Pit
A
Seaton Pit
Sea Bank
Water (Saturation line)
Five Quarter Seam
Main Coal Seam
Bensham Seam
Low Main Seam
Hutton Seam
Harvey
Brockwell
Seams proved workable
Seams expected workable
Seams proved not workable
Seams expected not workable
VERTICAL SCALE 60 FAS. TO 1 INCH.
HORIZONTAL SCALE 1 INCH TO 1 MILE.

stratification dip towards the sea at an angle somewhat more inclined than the surface of the ground, so that on this line of section the Magnesian-limestone crops out with a bold escarpment at X, about four miles inland from the sea, forming one of the most pleasing features in the landscape of the south-eastern portion of Durham. An observer standing on the escarpment and looking inland, would have an extended view over the wide expanse of flat country which, owing to the softer character of the rocks of the Coal-measures, lies at its base, and frequently running up into the Limestone in deep bays or fiords, gives it the character of an ancient rugged coast line. Seaward an entirely different aspect is presented—a series of undulating hills, intersected with many deeply-cut, picturesque and beautiful ravines, which being low and sheltered are well wooded and clothed with luxuriant foliage. The boldness of the escarpment is no doubt to a certain extent due to the soft nature of the "Yellow-sandstone" lying immediately at its base. This sandstone sometimes reaches a thickness of 50 feet, and extends over the flat base to a considerable extent beyond the Limestone, and being thoroughly pervious to water, forms a natural absorbent for all the drainage of the district around, which is further increased by the numerous before-mentioned bays running into the Limestone. In addition to this, over the country extending from the outcrop of the Limestone to the sea, the large fissures already spoken of as intersecting in all directions the Limestone, form so many channels of communication between the surface and the bed of "Yellow-sandstone" down which the surface drainage, and even in some instances small streams pass freely. It cannot, therefore, be wondered at that when this formation is pierced by any shaft below the level of saturation large volumes of water should be encountered; and although this may for the time increase the engineering difficulties and frequently add much to the cost of winning coal through the Limestone, it has at the same time its brighter points of view, affording as it does an inexhaustible supply of pure and agreeable water to the inhabitants residing on its surface. The large towns of Sunderland and South Shields are entirely supplied by water pumped at extensive works at Humbledon, Fulwell, and Cleadon Hills. The town of Seaham Harbour is also similarly supplied. The water is hard for domestic purposes, but delightfully clear and refreshing.

The following particulars of the Sunderland Water Works, which have been favoured to us by the Secretary, may be of interest:—

"All the reservoirs are at one level, viz., 220 feet above the level of the sea, and the shafts are sunk from the same level, except Fulwell, which is 140 feet lower than the reservoir.

"Humbledon Hill is sunk to a depth of forty fathoms all in Limestone, and in the bottom is a three inch bore-hole to a depth of fifty-four fathoms, which is in the Yellow-sandstone. The water stands in the shaft in the morning when there has been no pumping during the night, a little above twelve fathoms from the bottom, and by twelve hours pumping it is removed to seven or eight fathoms, there is great difficulty in getting it lower with the pumping power, which is equal to 1000 gallons per minute.

"Fulwell shaft is sunk to a depth of $23\frac{1}{2}$ fathoms, and is into the Yellow-sandstone about two fathoms. One million gallons per day have been lifted here when pumping twenty-four hours per day; the water stands, when not pumping at night, at eight fathoms from the bottom of the shaft, and after twelve hours' pumping, between two and three fathoms.

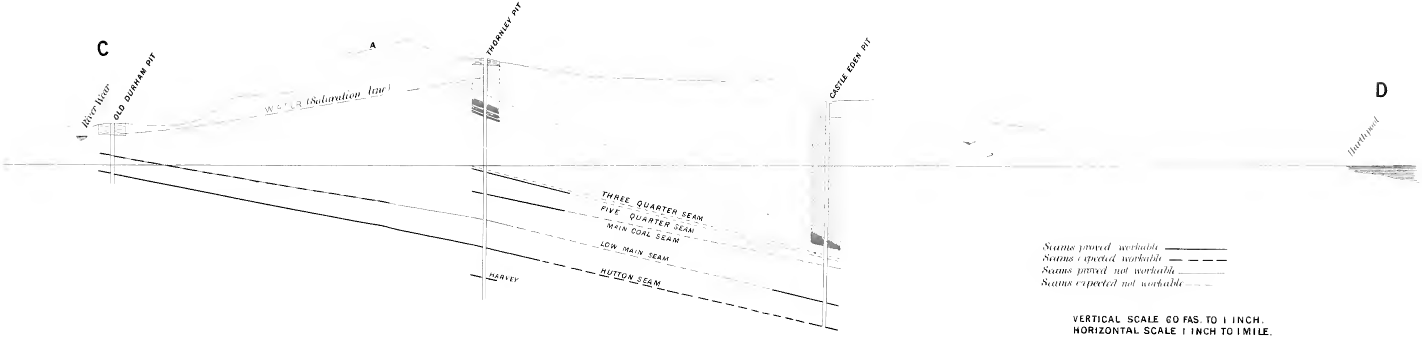
"The Cleadon shaft is sunk forty-five fathoms, all in Limestone, and the supply of water is very large; the pumps lift in twelve hours from one to $1\frac{1}{4}$ million gallons; the water stands in the shaft about eight fathoms from the bottom."

There is another point connected with this branch of our subject, which affords much scope for conjecture as to its cause, and offers a large field for further research. In all the deep winnings made near the sea-coast, the water met with below a certain depth is saline but not to a uniform degree, gradually becoming more so as the depth increases, until it attains the same specific gravity as the water of the North Sea. It is difficult to obtain the law regulating the increase of density, as a great number of experiments would require to be made extending over a considerable area, and great care that the waters tested are not locally contaminated by contact with decomposing rocks. The following, however, are the results of the testing of a great many samples obtained at various depths over the Hetton, South Hetton, Murton, and Seaham estates, extending over an area of about 30 square miles. (See Diagram No. 4.)

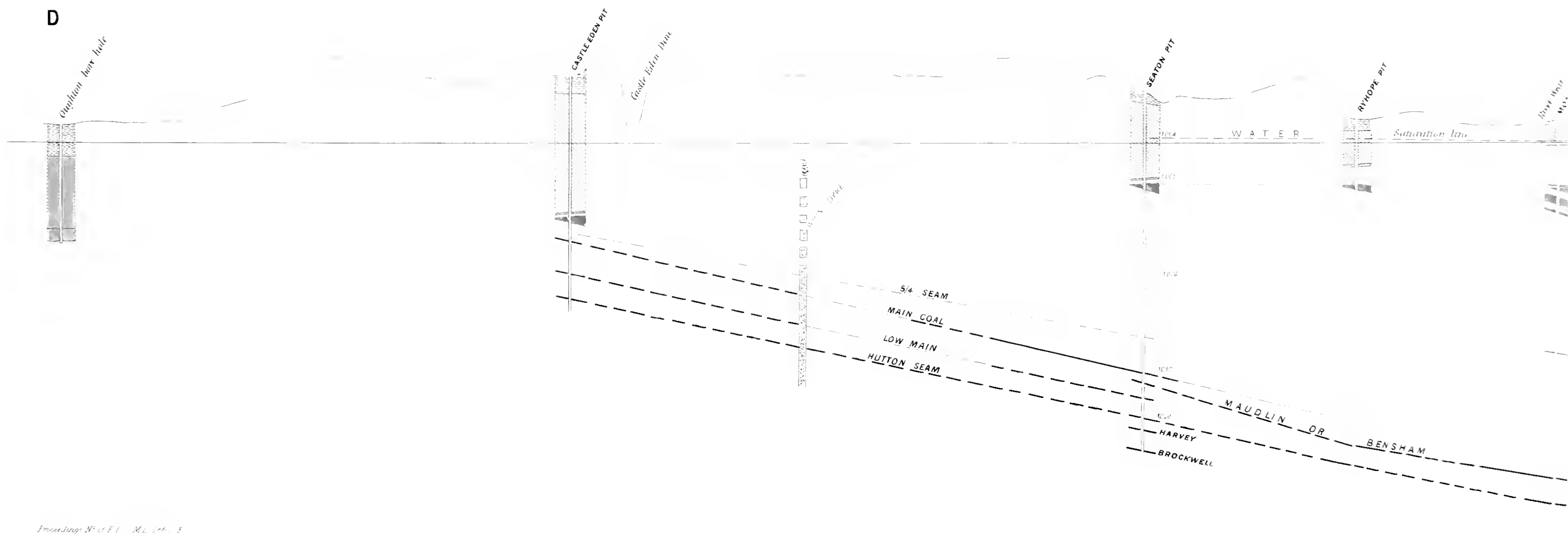
From this it would seem that the line of uniform saltness, so far as the above researches go, by no means follows either a line of uniform depth, or that of stratification, and does not depend on the contour of the country or the line of saturation.

The water of the greatest density was obtained from the roof of the Hutton-seam, at Seaton Colliery, at a depth of 1500 feet from the surface,

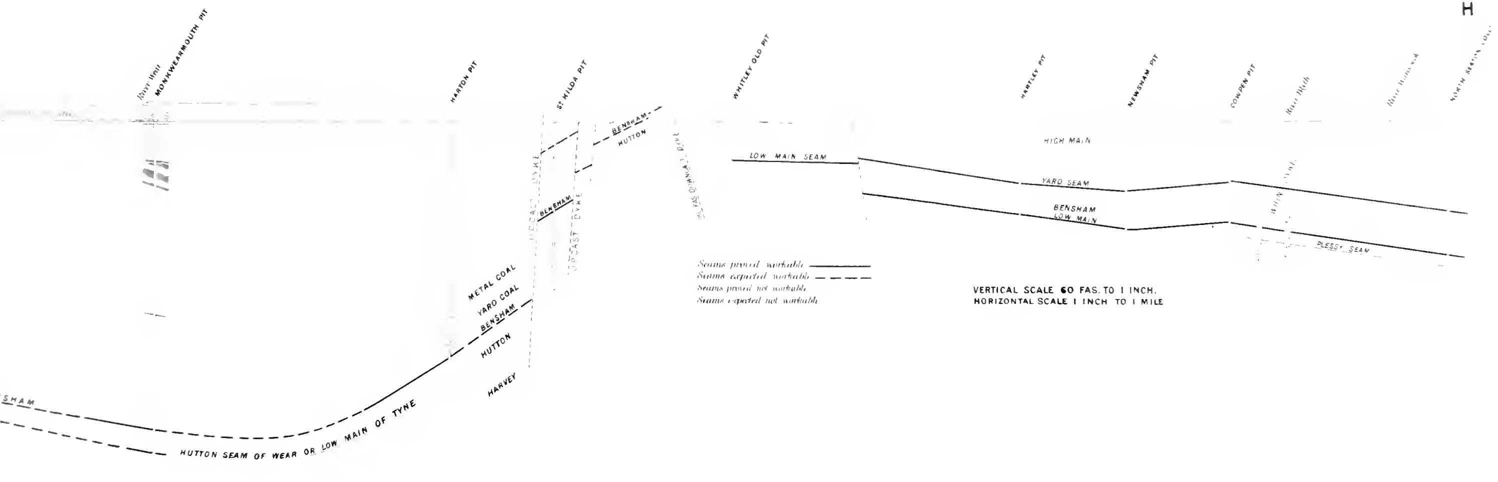
No. 3.


C
D
River Wear
OLD DURHAM PIT
THORNLEY PIT
CASTLE EDEN PIT
Hartlepool
A
WATER (Saturation line)
THREE QUARTER SEAM
FIVE QUARTER SEAM
MAIN COAL SEAM
LOW MAIN SEAM
HUTTON SEAM
HARVEY
Seams proved workable
Seams expected workable
Seams proved not workable
Seams expected not workable
VERTICAL SCALE 60 FAS. TO 1 INCH.
HORIZONTAL SCALE 1 INCH TO 1 MILE.

Nº 4.


D
CASTLE EDEN PIT
SEATON PIT
RYHOPE PIT
WATER
Saturation line
5/4 SEAM
MAIN COAL
LOW MAIN
HUTTON SEAM
MAUDLIN OR BENSHAM
HARVEY
BROCKWELL

No. 4.


H
MONKWEARMOUTH PIT
HARTON PIT
St. KILDA PIT
WHITLEY OLD PIT
HARTLEY PIT
NEWSHAM PIT
COWPEN PIT
BENSHAM
HUTTON
LOW MAIN SEAM
HIGH MAIN
YARD SEAM
BENSHAM
LOW MAIN
PLESSY SEAM
UPCAST DYKE
UPCAST DYKE
BENSHAM
METAL COAL
YARD COAL
BENSHAM
HUTTON
HARVEY
SHAM
HUTTON SEAM OF WEAR OR LOW MAIN OF TYNE
Seams proved workable
Seams expected workable
Seams proved not workable
Seams expected not workable
VERTICAL SCALE 60 FAS. TO 1 INCH.
HORIZONTAL SCALE 1 INCH TO 1 MILE

or 1260 feet below the level of the sea. This density was 1·026, being nearly that of sea water.

In other parts of this coal-field, however, as at Walker, Framwellgate, Butterby, Lambton, Birtley, and St. Lawrence, saline springs, of an entirely different character, are met with at various depths (in the case of Framwellgate and Butterby coming to the surface), and at some of these places the springs have been used as brine springs for the preparation of ordinary salt.

Various opinions are held by geologists as to the precise structure of the Permian series of this district, and their relationship to the subjacent rocks. Perhaps, with little exception, all the older geologists, and those not residing in this neighbourhood, consider the Permian series of this district to lie unconformably on the Coal-measures, and that the Yellow-sandstone and Red-sandstone beds form a part of the Permian series, and are conformable to the overlying Magnesian-limestone.

On the other hand, local geologists, whose opinions, from their opportunity of examination and from the attention which they have bestowed on this series of rocks, are well worthy of every consideration, are of opinion that the Yellow-sandstone and Red-sandstone beds form part of, and are conformable to the Coal-measures, and do not belong to the Permian strata. This view, however, does not seem to be borne out by well ascertained facts; questions of conformability, in all cases connected with the Yellow-sandstone, must be doubtfully entertained, as this rock lies more in hills than in beds; and the question of its conformability to the Limestone must be settled by examination over an extended area, as, indeed, is essential in order correctly to ascertain all questions of conformability. On Diagram No. 4 it will be observed, that whilst at Monkwearmouth Pit the Coal-measure strata intervening between the Magnesian-limestone and the Hutton-seam is 1500 feet, at Seaham it is 1100 feet, and at Castle Eden only 400 feet. So that at Castle Eden 1100 feet of Coal-measure strata has been denuded, and yet the Yellow-sandstone underlies the Limestone at each place.

With respect to the "red beds," it would seem to the writers that if they can be proved to be independent beds, they must also be conformable to the Limestone, resting with it unconformably on the edges of the coal strata; but for several reasons they venture to express an opinion that they do not exist at all as independent beds, but are merely the reddened edges of the Coal-measure rocks themselves.

The following are the reasons which have led the writers to entertain this view :—

1st. Beds of "red rocks" are frequently met with below the coal seams in sinking shafts, as is shown at Monkwearmouth, Ryhope, Seaton and Castle Eden, Murton and Eppleton, and Elemore Pits on Diagrams 3 and 4, indeed as can be seen cropping out below a coal-seam in the cliffs, a little to the north of Cullercoats Haven.

2nd. The fossil remains in the "red beds" are identical with those of the Coal-measures as shown by Mr. Howse in his Paper on the Permian Fossils. (Tyneside Naturalists' Field Club Transactions, Vol. III., p. 235.) And yet, if independent beds, they are not "the upper beds of the Coal-measures," because in all sinkings, etc., they are found to underlie the Limestone and Yellow-sandstone, even when, as previously mentioned, in treating of the unconformability of this rock to the subjacent coal formation, an enormous thickness of Coal-measure beds has been denuded off. Further, wherever any coal seam has been worked, as at Kelloe, Cornforth, etc., etc., nearly to its outcrop under the Limestone the stone forming the roof becomes red—clearly proving, either that these red measures are simply the reddened edges of the crop of the Coal-measures, or that they belong to the Permian series, resting unconformably with them, on the coal series.

3rd. This red appearance of rocks has been observed in other parts of the Coal-measures, where its origin could be distinctly traced.

1st. The shales forming the roof of coal seams are frequently found discoloured and reddened in the galleries of the mine, where they have been exposed to the action of the atmosphere for some time.

2nd. This character has been found strongly marked in the rock surrounding upcast shafts when the action of decomposition has been accelerated by increased temperature and probably by percolation of water.

3rd. In one special instance, viz., in the recent sinking of the Camboise Pit, which is situated close to the sea, and at the outset, passes through seven feet of recently-blown sand. The bottom of this sand was found to be quite reddened, and in appearance strongly resembled the red rocks below the "Yellow-sandstone," which latter, from its lying in hills, from its incoherent character and false-bedding, was probably originally blown sand.

It is not difficult to understand that the Coal-measure rocks, by lengthened exposure to the action of the atmosphere, as must have been the case prior to the deposition of the Limestone, would become reddened to the extent now witnessed, when it is considered that they all contain so large a quantity of iron, and that, under circumstances at all favourable, they readily take on them this character.

The writers propose now to treat shortly of the general stratigraphical character of the Magnesian-limestone of this district.

Hitherto, it has been usual for geologists to divide this formation into four distinct beds, or groups of beds; and these sub-divisions have been compared to other series of beds extensively developed in other parts of Europe.

These groups of Ma gnesian-limestone rocks have been named by the following authors thus :—

In 1850, Professor King published the following arrangement of the Magnesian-limestone :—

In England.	In Germany.
1. Crystalline	Stinkstein
Brecciated Pseudo-brecciated	Rauchwacke
Fossiliferous	Dolomit
Compact	Zechstein

In 1857, Mr. Howse proposed the following division of the Magnesian-limestone, which has been adopted by Mr. Kirkby and Professor Geinitz, of Dresden, and also by Professor King more recently :—

English Series.		German Equivalents.
	Magnesian-limestone.	*Zechstein.*
1. Upper Group.........	*a* Upper-yellow-limestone	*a* Plattendolomit, and
	b Botryoidal do.	*b* Kugelkalk, etc.
2. Middle Group	*c* Cellular, and	*c* Rauchwacke
	d Shell-limestone	*d* Dolomit, Asche, etc.
3. Lower Group	*e* Compact limestone, and *f* Conglomerate	*e* Zechstein

Doubtless, any one examining these rocks, by commencing at their outcrop near South Shields, which is the usual starting point, and going Southward along the coast, would readily recognise these groups. The line of separation between the Compact and Cellular rocks is clearly distinct, as is also the first appearance of the Botryoidal Rocks, South of Marsden. But there are equally well-defined changes in the character of the rocks at other points along the coast (as at the point near the blast furnace South of Seaham Harbour) which have not been made use of for grouping the Magnesian-limestone into distinct series of beds ; and there are also, South of Seaham, several other groups of shell rocks with distinct and variously-marked differences of lithological character. It is not at all to be wondered at that these points of strongly-marked difference of lithological character, and apparent nonconformability of deposition, should occur throughout such an extensive deposit as the Magnesian-limestone. These occur constantly to a far greater extent throughout the Coal-measures, and yet it would be extremely hazardous to venture on any speculative subdivision of those rocks ;* most probably all the variations of lithological structure running through all the stages of friable, earthy, rubbly, starry, marly, crystalline, botryoidal, coralloidal, spheroidal, mammillated, breccia, and pseudo-brecciated, soft-laminated, and hard-laminated, conglomerate, conglobate, concretionary, oolitic and honeycomb, are simply due to the effects of local action at the time of deposition-rocks of the same stratigraphical position taking alternately any or all of the above lithological type.

Another subject for legitimate research is the connection between the dislocations affecting the Coal-measures and the Magnesian-limestone.

The great upheaval to the west which has more or less affected the whole of the British Islands, has evidently taken place after the deposition of the Limestone, as in this direction the Magnesian-limestone is lifted up in the same manner as the Coal-measure (see Sections 2 and 3), both rising rapidly to the west.

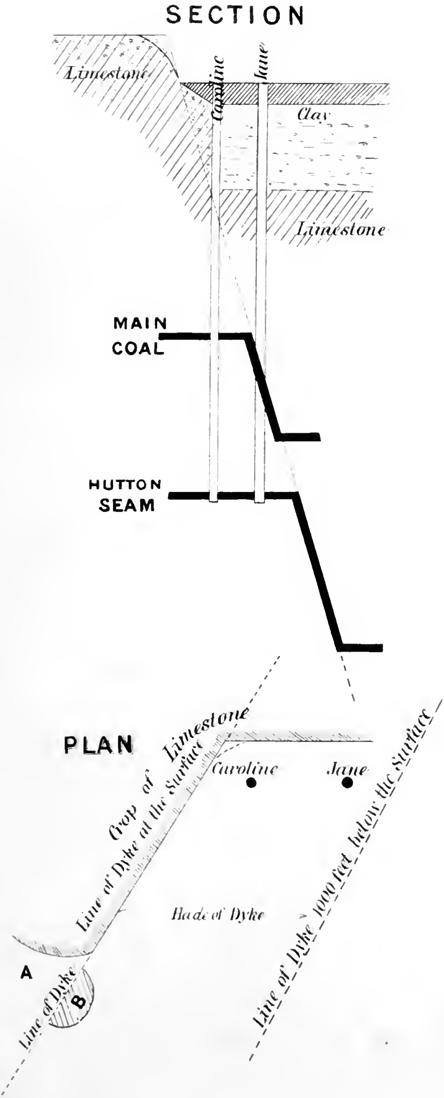
It is quite possible that the minor faults have been caused by this, as they generally run in a direction comparatively at right angles to that of the main fault.

Many of these can be proved to pass through the limestone. The following instance is an additional one to others already communicated. (See Diagram 5.)

A forty feet upthrow fault, to the west, passes through both the "Jane and Caroline" shafts of the Eppleton Hetton Colliery, the depth to the

* The roof of a seam of coal consists at one place of a hard sandstone, which, thinning out more or less abruptly, is replaced by soft shale, and at times the shale comes in as a wedge, without displacing the sandstone and gradually increases to a thick bed. Even beds of coal themselves, commencing with a few inches, thicken to many feet, are separated by layers of shale into distinct seams, and again become one by the disappearance of the band of shale.

Nº 5.



Lithographed by A. [illegible] Newcastle

Hutton-seam being 1100 feet. The fault is met with 200 feet to the west of the bottom of the Jane Pit, and 100 feet to the east of the Caroline shaft on the surface, so that the hade is 300 feet in 1100.

At the sinking of the Caroline shaft there was thirty feet of clay before the Limestone was reached, although it forms the escarpment of the hill fifty feet above the top of the shaft, and 100 feet to the south of it, clearly proving that the Coal-measures and the Magnesian-limestone have been equally affected by the upheaval.

The bare escarpment of the Limestone runs along the line of the trouble about half a mile, and is quarried at A on the Diagram, the Yellow-sand forming the floor of the quarry; and being itself extensively worked. But the limestone is again quarried at B, where it is thrown in by this fault.

In endeavouring to trace accurately the true line of outcrop of the limestone, it is essentially necessary to take the action of these faults into consideration.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

ANNUAL MEETING, THURSDAY, AUGUST 4, 1864, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, Esq., President of the Institute, in the Chair.

The President introduced Mr. Howell, who was about to visit the district to complete the geological survey for the Ordnance maps. He (the President) had a letter from Sir Roderick Murchison, asking him to introduce Mr. Howell to the members of the Institute, and to give him all the information he could on the subject of his visit. He had promised to do so, which, indeed, he felt bound to do as President of the Institute, and was sure that he expressed the feeling of the meeting when he said that every member of the Institute would be happy to do the same. It was very important to have an accurate delineation of the geology of the district.

Mr. Potter—You will give the outcrops of the principal seams of coal.

Mr. Howell—Yes.

The Secretary then read the minutes of the Council, the Annual Report, and the Report of the Finance Committee.

The following gentlemen were elected members of the Institute:—Mr. David Llewellin, Pontypool (in the place of his brother William, deceased), and Mr. Norman Cookson, Newcastle-upon-Tyne.

The President said, that at the meeting of the Council to-day, a copy of rule No. 22 was ordered to be forwarded to Mr. Reid, with instructions for him to act in accordance with it. The rule is this—"The Transactions of the Institute shall not be forwarded to members whose subscription is more than one year in arrear." The rule formerly was "more than two years in arrear;" but the Rules Committee recommended the former, which was sanctioned at the ensuing general meeting, and, therefore, this was the rule in operation at present. The time the subscriptions are due is stated in Rule 6 to be the first of August in each year. He thought it necessary that this should be noticed, because there were twenty-four members in arrear, and, consequently, the Transactions would not be sent to them. There was another matter connected with this, which he thought it his duty to notice, as there were eight members whose subscriptions were two years in arrear. There was no rule bearing directly on this subject, but there was an understanding if a member was two years in arrear he should no longer be deemed a member of the Institute. This, he believed, had been acted upon, and the name of the member was struck off the list of members, and the proceedings of the Institute were not forwarded to him. He (the President) did not think there was any rule to that effect; but a member would be substantially expelled if he did not get the Proceedings. He might afterwards present himself for reëlection.

Mr. Hall said, all these persons might be put on the list, on their subscriptions being paid up.

The President—It would be better to refer the matter to the Rules Committee.

Mr. L. Wood—They have all had notice that they would be struck off the list of members if their subscriptions were not paid, and some members had, consequently, paid their subscriptions.

The President then moved, that the attention of the Rules Committee be directed to the case of members who are two years in arrear with their subscriptions, and also to the election of the Secretaries, and that they be requested to report to the next general meeting on these subjects.

The motion, on being seconded, was carried by a show of hands.

The President said, he could not help remarking that a very good resolution was proposed by Mr. T. E. Forster, and adopted at the last annual meeting, namely, that the members use their influence with their employers to induce them to subscribe to this Institute. He regretted that this did not seem to have had the salutary effect on them which might have been expected. They had not received any subscriptions in addition to those they had had before. He only hoped that members would continue to use their influence as Mr. Forster had proposed, and that they might be more successful in the year to come. There was another subject which had come before him, from a member of the Institute, and that was with reference to having a meeting in some distant and suitable locality, at some convenient time in the course of the year. They were all aware of the beneficial effect which resulted from their meeting at Birmingham. The standing which such a meeting gave to the Institute was very beneficial, and it certainly was extremely useful in obtaining papers for the Transactions of the Institute. He thought their finances were in such a state as would enable them to have, during the next year, another meeting in some locality to be fixed upon after due consideration. If the meeting thought it advisable that such a subject should be discussed, then, probably, the best course would be to direct the attention of the Council to the subject, with the view of having such a meeting during the year 1865. It had been suggested that Manchester was a proper place, being in the vicinity of extensive collieries, and there was also the circumstance of there being a Geological Institution at Manchester. South Wales was also pointed out as a locality in which a great deal was doing that would be interesting to the Institute. He thought, therefore, it would be worth while to hold a meeting either at Manchester or South Wales. He therefore moved, "That the Council of the Institute be directed to take into consideration the propriety of holding one of the general meetings of the Institute in some locality most convenient and proper for the objects of the Institute, and report their labours to the next general meeting."

Mr. Hall seconded the motion, which was carried unanimously.

The President said, he would now only congratulate the members of the Institute on their present position, which was eminently satisfactory, excepting always the attendance, which he regretted they could not command to a greater extent. To-day they had five different subjects for discussion, and there were not twice five members present to discuss them; though the discussion of papers at the annual meeting not being usual, from the quantity of other business, may have been the cause of the non-attendance.

Mr. Daglish presented a paper by Mr. R. C. Clapham and himself "On the Minerals and Salts found in Coal Pits."

The following resolution was then adopted:—That the discussion of the papers announced for to-day, together with that of Mr. Daglish and Mr. Clapham, on Minerals and Salts found in Coal Pits, now read, be postponed; and that the members be specially summoned for their discussion at the next general meeting.

The meeting then separated.

ON

MINERALS AND SALTS FOUND IN COAL PITS.

By R. CALVERT CLAPHAM and JOHN DAGLISH.

In conducting the extensive coal-mining operations of the counties of Northumberland and Durham, many interesting minerals and salts are met with, which are little noticed by mining adventurers, as they do not bear directly on the material sought for. Some of these substances have been formed simultaneously with the coal, or at least at periods far removed from the present time; others are of recent formation. Having had favourable opportunities of obtaining and examining specimens, the writers propose briefly to exhibit and describe some of these, grouping them under three heads:—

1st.—Coal and the adjoining rocks which were formed nearly simultaneously with it.

2nd.—The Minerals and other foreign substances found in coal.

3rd.—The Salts found in coal, and formed by decomposition and recombination.

1.—COAL.

One of the most striking peculiarities of the Northern Coal-field is the variety in the economic quality of the various beds of coal—the same seam being in different parts a household, a gas, a coking, and a steam coal, and this occurs without any great alteration in its chemical constituents, and probably arises from a different combination of the same elements, or in mechanical structure. This may be illustrated by the following analyses taken from the Parliamentary Report on the coals suited to the steam navy.

I.—Caking coal from Tanfield Colliery, Andrew's House, Hutton Seam:—

Per centage of Coke.	Sp. G.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.
65·13 ...	1·26 ...	85·58 ...	5·31 ...	1·26 ...	4·39 ...	1·32 ...	2·10

II.—Steam coal from Cowpen Colliery (Low Main-seam), Hutton of Wear:—

Per centage of Coke.	Sp. G.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.
58·59 ...	1·26 ...	82·20 ...	5·10 ...	1·69 ...	7·97 ...	·71 ...	2·30

III.—Household coal from Haswell Colliery, "Haswell Wallsend" (Hutton seam):—

Per centage of Coke.	Sp. G.	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	Sulphur.	Ash.
62·70 ...	1·286 ...	83·47 ...	6·68 ...	1·42 ...	8·17 ...	0·6 ...	0·20

The *household coal* has a hard fracture, and in burning leaves little ash, and that of a dark colour. The essential economic character of *gas coal* is the yielding of a large quantity of gas on distillation, together with freedom from sulphur and other impurities. The requisite of *coking coal* is that on roasting in close ovens it should yield a hard and compact coke, free from sulphur and from slaty particles, which latter on burning would leave clinkers, and destroy the fire bars. The *steam coal* is a very hard, free burning, white ash, non-caking coal.

A curious circumstance may be here briefly alluded to. The same seam, viz., the Hutton-seam, on the Wear, whilst altering its character in various parts of the district, always furnishes coal of good quality in its class. Thus from the Hetton, Haswell, Pittington, and Littletown Pits it commands the highest prices as a "household coal." At Springwell, Usworth, and Pelton, etc., it yields the best gas making coal in the district. At Tanfield excellent coke is manufactured from this seam, and from Cowpen and the adjoining pits it is sold to a very large extent as "Hartley" coal, for the use of steamships. With rare exceptions all the seams in one district have the same economic character.

The rocks adjoining the coal consist chiefly of bituminous and non-bituminous shales, sandstone, ironstone, and limestone, and although they possess numerous distinctive features of very great interest, a lengthened description would be foreign to the purpose of this paper, and is the less required, as their general properties have been frequently described, and are well understood. Specimens are, however, exhibited, and a brief analysis of each is annexed for the object of showing more clearly the part they play in the formation of the Salts, etc., hereafter to be described. The following are the specimens selected:—

1st.—Specimen of non-bituminous grey shale, from Messrs. Cowen's Pit at Blaydon.

2nd.—Specimen of non-bituminous blue shale, from Newsham Colliery, near Blyth.

3rd.—Specimen of bituminous shale from the roof of the Low Main or "West Hartley" seam, at same mine.

4th.—Specimen of mussel band ironstone, from a bed lying five feet above the Low Main-seam, in the Bedlington Pit, and of clay ironstone from Hetton Colliery.

5th.—Specimens of sandstone.

	1	2	3	4	
				Mussel Band. Clay Ironstone with Shells.	
	Fire-clay.	Blue Shale.	Bituminous Shale.	Sol. in Acid.	Insol. in Acid.
Silica Acid	55·500	52·452	34·276	trace	31·068
Alumina	27·753	23·290	19·347	1·194	16·292
Lime	0·668	0·598	1·027	4·084	0·988
Magnesia	0·746	1·377	0·519	1·078	0·288
Potash	2·819	2·089	0·893	1·319	
Chloride of Sodium	0·439	..	soda	..	
Sulphate Soda			0·734	trace	
Peroxide Iron	2·008	4·569	4·275	..	
Protoxide Iron	..	4·545	..	18·637	
Water of Combination	10·524	11·083	..	11·221	
Hydrogen	..	..	2·630	..	
Oxygen	..	..	9·090	..	
Nitrogen	..	..	·934	..	
Carbon	..	..	26·709	..	
Carbonic Acid	..	..	..	14·057	
	99·327	100·003	100·065	51·590	48·636

The chief characteristics of the sandstones seem to be the quantity of iron, lime, or magnesia they contain, which is the cause of their decomposition when exposed to the action of disintegrating agents, and has led to serious loss through the decomposition of the stones with which the sides of many of the upcast shafts in this district are lined, by the sulphurous vapours from the ventilating furnaces and engine fire. This is remedied by the adoption of fire-bricks in the place of sandstone, the latter not being liable to decomposition under the circumstances to which they are exposed.

NOTE.—With the object of showing the action of these gases, the writers have examined various specimens of metal tubbing, taken from the shafts of Hetton and other collieries, after having been some years in use, and append the analysis:—

	No. 1.	No. 2.	No. 3.
Iron	72·00	59·20	
Sulphur	3·00	3·28	2·05
Carbon	3·85	25·72	
Silica	0·65	..	
Water	16·00	14·72	
	95·50	100·00	

The following are some analyses of sandstone:—

	Pensher. Brown Rock.	Pensher. White Rock.	Pensher. Grey Rock.		Cox Green. Top Stone.	Cox Green. Middle Stone.	Cox Green. Bottom Stone.		Cragtieth Sandstone.	Micaceous Sandstone.
Silica	78·50	88·00	84·50	..	78·83	81·60	83·30	..	86·33	76·25
Alumina ..	16·00	10·00	5·50	..	12·16	9·60	9·16	..	9·83	8·12
Oxide of Iron	5·00	1·16	5·30	..	6·00	6·60	6·00	..	2·60	9·53
Carbon. Lime	0·21	0·20	0·30	..	1·40	1·20	0·34	..	1·60	1·11
Carbonate Magnesia	0·30	0·20	trace	..	0·30	0·40	0·30	..	trace	0·32
Salts of Soda & Potash	trace	trace	trace	..	trace	trace	trace	..	trace	3·40
	100·01	99·56	95·60		98·69	99·40	99·30		100·36	98·73

In this district there are no instances of limestone being associated with the coal beds; but this rock is largely developed in the *Mountain-limestone* series underlying the Coal-measures of the North and West, and in the *Magnesian-limestone* series overlying them in the South-eastern portion of the coal-field. Although the lower limestones are frequently called carboniferous, they sometimes contain magnesia; whilst the so-called Magnesian-limestone is in some cases free from magnesia. Thus, the white bed in the Magnesian-limestone quarry at Whitley is stated by Mr. Taylor, in his paper to the Institute of Mining Engineers, Vol. IV., to contain only one per cent. of magnesia; and, on the other hand, the top bed of the Carboniferous-limestone quarry in Holy Island contains 35 per cent. carbonate of magnesia. One of the writers has also pointed out, in a paper in the Transactions of the Tyneside Naturalists' Club, that the Magnesian-limestone rocks near Marsden contain nodules of pure carbonate of lime; but, on the whole, the general character of the upper limestones is, that they contain magnesia, which is of rarer occurrence in the limestones below the coal.

The following is an analysis of Magnesian-limestone:—

Carbonate of lime	57·50
Carbonate of magnesia	35·33
Silica	5·00
Alumina	1·60
Peroxide of iron	0·50
	99·93

2.—MINERALS AND OTHER FOREIGN SUBSTANCES FOUND IN COAL.

Many of these are omitted in printed analyses, as they exist in separate masses, and are not uniformly intermixed throughout the coal. They chiefly consist of—

(1.) Carbonate of iron.	(6.) Sulphate of baryta.
(2.) Sulphuret of iron.	(7.) Hatchetine.
(3.) Sulphuret of copper.	(8.) Coprolites.
(4.) Sulphuret of lead.	(9.) Arsenic.
(5.) Carbonate of lime.	(10.) Sulphuret of nickel.

(1.) Specimen of *carbonate of iron,* found in balls and layers, and frequently mixed with lime; also in large masses.

(2.) *Iron pyrites,* locally termed "brasses," is found in nearly all coal, and sometimes to a very considerable extent. A large quantity is separated from the coal on its arrival at the surface of the mine; of this a great part is thrown to waste, forming the "fire heaps" attached to nearly every colliery.

Probably as much as 20,000 tons per annum are saved, and used in the manufacture of sulphate of iron and sulphuric acid.

The following is an analysis of cleaned coal pyrites from Walker Colliery:—

Sulphur	40·50
Iron	36·35
Coal	17·90
Silica	1·55
Carbonate of lime	4·00
	100·30

Generally the iron pyrites is found running through the coal in veins, balls, or isolated aggregations of crystals, but in some cases it is finely interspersed throughout the entire mass; and in a case instanced by Professor Ansted, in his recent work on Hungary, it causes the rapid crumbling of the coal by its decomposition on exposure to the atmosphere.

Iron pyrites decompose when exposed to a moist atmosphere, and more readily if the temperature be raised, becoming sulphuret of iron, and then sulphate of iron; one atom of sulphur combining, either with hydrogen to form sulphuretted hydrogen, or with oxygen to form sulphuric acid. The former probably results from the exposure of iron pyrites to a damp atmosphere, without contact with any substance with which the sulphur can recombine; as, for instance, when the pyrites is in contact with coal only, and causes the disagreeable odour existing in many of the old passages in coal mines. In the latter case, when sulphuric acid is found, it attacks the aluminous shales, and various salts, hereafter to be described, are resultants.

(3.) Specimen of copper pyrites from the centre of the Hutton coal seam at Seaton Colliery, near Seaham, at a depth of 1500 feet. It consists of *sulphurets of iron and copper*. Its analysis is as under:—

Copper	33·20
Iron	28·20
Sulphur	37·00
Carbon, &c.	1·60
	100·00

The writers believe that sulphuret of copper has not before been noticed in large and distinct masses embedded in coal.

A specimen of *carbonate of copper*, found in the Magnesian-limestone at Ferry Hill, is also exhibited, but was not analysed.

(4.) Specimen of *sulphuret of lead* (galena), also taken from a vein in the Hutton seam, Seaton Colliery. The occurrence of these veins is not so uncommon as in the case of the sulphuret of copper. The coal in their vicinity being perfectly unaltered, affords proof of their deposition by segregation or from solution; for had heat been present, the coal would have been charred in a similar manner to that which has been subjected to the action of a whin dyke.

The following is an analysis of a specimen:—

Lead	52·48
Sulphur	11·40
Iron	2·10
Coal, &c.	34·02
	100·00

(5.) Specimen of *carbonate of lime*, generally found in layers or veins.

(6.) Specimen of *sulphate of baryta*, found in Felling Colliery, near Newcastle, by Mr. G. B. Forster, in quite a large mass. The writers are not aware of sulphate of baryta having previously been noticed in connection with coal, except by Dr. Richardson, of Newcastle, who observed it in the waters of Walker Colliery in 1847.

(7.) Specimens of *hacthetine*. Amongst the most curious of the minerals found *in sitû* in coal mines, is the naturally-formed solid hatchetine. Some of this substance was found in the Urpeth Pit, some years since, and is described in the Transactions of the Newcastle Natural History Society. More recently, some of it was found in the Seaton Pit, and exhibited to the members of the Northern Institute of Mining Engineers. Still more recently, a quantity was found in the South Hetton Pit, some of which the writers hoped to have been able to lay before the members of the Institute, but unfortunately the pit boys found it out, and used it for greasing the axles of their trams, thus making it deserve the name of "mineral grease," which it sometimes receives.

(8.) Specimen of *coprolite* found in the bituminous shale lying immediately over the Low Main seam at Newsham Colliery, near Blyth. From the numerous fish remains found in this bed, it has received the name of "Fish Bed." This specimen contains 30 per cent. of phosphate of lime.

(9.) Arsenic is not found isolated, but in some coal brasses it exists to the extent of 0·1 to 0·3 per cent.

(10.) Specimen containing fine crystals of sulphuret of nickel imbedded in carbonate of iron, from South Wales.

3.—SALTS FORMED BY DECOMPOSITION AND RECOMBINATION.

Through the rocks described in the first part of this memoir, water is constantly percolating and becoming charged with various salts in its passage through the upper strata, induces decomposition of many of the previously mentioned substances, thus forming new combinations. These are in some cases found in solutions of various densities, sometimes in crystallised masses of great purity, and at other times in layers deposited from solution or by evaporation. We here give a few illustrations.

(A) A specimen from Hetton Colliery, which consists of crystallised *sulphate of iron* (copperas). This is sometimes found in considerable quantities.

In the same pit, a solution is met with resulting from the decomposition of iron pyrites, which is of so high a specific gravity, as to present the curious spectacle of large blocks of coal floating on its surface. In some samples the specific gravity was 1·340. Bi-sulphuret of iron occupies a very important part in the various decompositions which are constantly taking place in the shales, &c., of the Coal-measures. Owing to the affinity between sulphur and iron, being nearly equal in intensity to the affinity between oxygen and iron, very slight variations in circumstances and condition, induces decomposition. On the one hand we have in the specimen exhibited, evidence of the decomposition of the bi-sulphuret of iron by oxidation, whilst the reverse action is exemplified in the purification of coal gas, in the formation of sulphuret of iron, by the absorption of hydrogen from sulphuretted hydrogen by the peroxide of iron which becomes deoxidized. The salts of iron, when in solution, act most destructively on pipes and other metal work. By exposure to the atmosphere, the sulphate of iron is converted into a per-salt, and in this form, having only a slight affinity for sulphur, parts with the greater portion as sulphuric acid, which acts most vigorously on the iron, and in one instance at Wingate Grange Colliery, an expense of nearly £4,000 was incurred in one year in repairing pumps. (See a paper contributed by Mr. Wm. Armstrong to the Northern Institute of Mining Engineers.) In this case (according to Dr. Richardson) the analysis of the water gave in 1000 parts:—

Sulphate of iron	3·51
Sulphate of alumina...	0·53
Sulphate of lime	1·89
Free Sulpuric Acid	1·64

(B) Specimen of *sulphate of alumina*, containing 29·7 per cent. sulphate alumina, soluble in water. This substance is found in considerable quantities in Hetton Colliery.

(C) Specimen of *sulphates of iron and alumina* (iron alum very pure). This is found in fine crystallised masses.

(D) Specimen of *sulphate of lime*, from *Walker Colliery*, from a large mass of snow-like crystals.

(E) Specimen of needle-shaped crystals, *sulphate of magnesia* (Epsom salts). This substance is found in large quantities in Hetton Colliery, and is quite pure.

(F) Specimen of nearly pure *chloride sodium* (common salt) with a trace of sulphate of lime.

(G) Specimen of *chloride of potassum*, mixed with common salt.

INDEX TO VOL. XIII.

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